the future of southern california

Murrieta

General Plan Update

Appendix G:

Seismic & Geologic Hazards Existing Conditions Report

SEISMIC AND GEOLOGIC HAZARDS REVIEW
GENERAL PLAN UPDATE
CITY OF MURRIETA, CALIFORNIA

Prepared For:

CITY OF MURRIETA
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Project No. 602728-001

January 8, 2010

Leighton Consulting, Inc.
A LEIGHTON GROUP COMPANY

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CITY OF MURRIETA
c/o RBF Consulting
14725 Alton Parkway
Irvine, CA 92618

Attention: Ms. Collette L. Morse, AICP, Vice President

Subject: Seismic and Geologic Hazards Review
General Plan Update, City of Murrieta, California

In accordance with your authorization and our proposal dated June 26, 2009, we have performed a seismic and geologic hazards review for the City of Murrieta (City) in support of the General Plan Update. This report summarizes our findings and provides general recommendations related to potential seismic and geologic hazards within the City. Future land developments within the City limits appear feasible from a seismic/geologic viewpoint provided independent, site-specific evaluations are performed to address the general concerns and constraints outlined in this report.

If you have any questions regarding this report, please do not hesitate to contact the undersigned. We appreciate this opportunity to be of service on this project.

Respectfully submitted,
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1.0 INTRODUCTION

1.1 Purpose and Scope

The purpose of this study was to compile and summarize the known seismic and geologic hazards within the City of Murrieta General Plan study area and provide an overview of the known typical geotechnical constraints that might be expected during future land development. More specifically, our scope for this report included the following:

- Establish a geo-referenced maps for the entire City,
- Review in-house and published geologic reports/maps (USGS, CGS, Riverside County, etc.) and transfer pertinent data to the geo-referenced maps,
- Review historic and current aerial photos to evaluate for past or potential geologic hazards specifically for the three (3) specified corridors,
- Provide a general description of the type of native soil and rock units throughout the City,
- Present the potential geologic hazards within the City including mapped fault traces and County and/or State of California Alquist-Priolo (AP) Earthquake Fault Zones. Additionally, areas that are prone to liquefaction or dry seismic settlement, and other seismic hazards such as ground rupture, rock fall hazards, landslide and subsidence are also discussed,
- Present the historic seismic activity within the City area and provide typical Seismic Design Criteria per the current 2007 California Building Code,
- Discuss the potential for encountering shallow groundwater during development of certain areas of the City,
- Discuss the general rippability characteristics of potentially bedrock units in certain areas of the general plan based on exiting in-house data. The report also includes general description of previously used methods of rock excavation/reduction as well as onsite rock disposal/placement methods,
- Discuss the potential for encountering hazardous naturally occurring minerals,
- Summarize potential mass grading challenges within specific areas of the City based on past experience, and
- Describe typical foundation types used and provide generalized geotechnical foundation design recommendations for future structures.

1.2 City Location and General Description

The City of Murrieta is located in southwest Riverside County, north of the City of Temecula and south of the Cities of Menifee and Wildomar. The City consists of approximately 45 square miles of land, which has experienced significant growth in residential development since the first General Plan in 1994. We understand that this General Plan is currently being updated to address the overall City growth and in particular, future development within three specific study areas or corridors, which have the potential to attract businesses and promote diversified job creation for City residents. As such, these three areas or corridors will be specifically evaluated in this report and pertinent geotechnical constraints during future land development are briefly discussed. These corridors will be referred to in this report as Areas 1 through 3 and may be generally described as follows:

- Area 1- Southwest Murrieta / Jefferson Business Corridor: This area is currently the major retail and light industrial agglomeration within Murrieta and located generally west of the Golden Triangle along the west side of Interstate I-15, south of Kalmia Street and north of the City's southern boundary.

- Area 2 -Golden Triangle: This area is generally located north of the intersection of I-15 and I-215 and south of Los Alamos Road.

- Area 3 - Northeast I-215 and Clinton Keith Road: This is generally the northeastern quadrant of the City located along the east side of I-215 and north of Clinton Keith Road where relatively most vacant land currently exists.

2.0 GEOLOGY

2.1 Regional Settings

The City of Murrieta (City) is located within the northern portion of the Peninsular Range geomorphic province which is characterized by steep, elongated ranges and valleys that generally trend northwestward from the tip of Baja California to the Los Angeles Basin. The City is regionally located at the base of the Santa Ana Mountains and the Santa Rosa Plateau. The Santa Margarita and Agua Tibia ranges are approximately 12 to 14 miles to the south, and the San Jacinto ranges lie approximately 35 miles to the east.

More specifically, the City is situated within two structural blocks or subdivisions of the Peninsular Range province. The western foothill boundary of the City is within the Santa Ana Mountains block and the east portion is within the Perris block. These provinces are separated by the active Elsinore fault zone, which forms a complex pull-apart basin (locally known as the Murrieta-Temecula Valley) that is filled with sedimentary deposits. The relatively stable Santa Ana Mountains and the Perris Block are underlain by pre-Cretaceous aged metasedimentary rocks and Cretaceous aged plutonic rocks of the Southern California batholith. Tertiary-aged sediments, volcanics and Quaternary-aged sediments flank the Santa Ana mountain range to the west, elevated portions of the valley floor, and within the western flanks and localized valleys of the Perris Block. The Quaternary sediments include the "Unnamed" Sandstone, Pauba Sandstone, Pauba Fanglomerate, and younger alluvial sediments (Kennedy, 1977).

2.2 Area Geology

The City is underlain by numerous surficial deposits and/or bedrock units based on published geologic maps (Figure 1). The major surficial deposits and bedrock units that are most likely to be encountered during future developments are briefly described below:

- **Artificial Fill (not a mapped unit):** Artificial fills are generally referred to as undocumented fills or engineered (documented) fills. Undocumented fills are typically those fills that were placed without the review and testing of a geotechnical consultant. Engineered fills are those fills that were observed and tested by a geotechnical consultant. Most artificial fills within the City are expected to be engineered and placed during construction of existing public roads and private developments. The engineering characteristics and vertical or horizontal extent of these fills are site-specific.

- **Colluvial Deposits (not a mapped unit):** Colluvium is the name for sediments that have been deposited or built up at the bottom of a low-grade slope or against a barrier on that

slope, transported by gravity. These deposits generally consist of silty sand and sandy gravel with abundant angular and sub-angular fragments of the underlying bedrock units.

- **Young Axial-Channel Deposits (map symbol Qya):** These alluvial deposits (late Holocene) are generally found in active stream beds, flood plains or channels and consist of unconsolidated to locally poorly consolidated sand and gravel with small amounts of silt.

- **Young Alluvial-Valley Deposits (map symbol Qyv):** These alluvial flood plain deposits (Pleistocene, younger than 500,000 years) are generally found along the main Murrieta Creek channel and expected to exceed 100 feet in depth. These deposits cover positions of Area 1.

- **Very Old Alluvial Channel Deposits (map symbol Qvoa):** These alluvial deposits are generally deposited on canyon floors and consist of moderately to well-indurated, reddish-brown mostly dissected gravel, sand, silt and clay. These deposits are generally found in the northeastern portion of the City.

- **Pauba-fanglomerate (map symbol Qpf):** The Pauba-fanglomerate member (Pleistocene) is well indurated, poorly sorted fanglomerate and mudstone and generally found along the east flank of the Santa Ana Mountains (west of the City).

- **Pauba-sandstone (map symbol Qps):** The Pauba-sandstone formation (Pleistocene) is poorly to moderately well-indurated, extensively crossbedded, channeled and filled sandstone and siltstone that contains local intervening cobble-and-boulder conglomerate beds. This formation is generally found in the southern half of the City including most of Area 2 and portions of Area 1.

- **Sandstone and Conglomerate of Wildomar area (map symbol QTws)):** This formation consist primarily of friable, pale yellowish-green, medium grained, caliche-rich sandstone and located in middle portion of the City, just north of the Golden Triangle Area.

- **Basalt of the Hogbacks (not mapped):** The locally named Hogbacks are an elevated hilltop located in the eastern portion of the City. Capping this unique feature is a remnant channel filled with basalt (Tertiary-age).

- **Gabbro (map symbol Kgb)**: This Cretaceous-age granitic formation also constitutes portions of the hills along the northern part of the City and underlies the older alluvium in Area 3 (Northeast I-215 and Clinton Keith Road).

- **Monzogranite to Granodiorite (map symbol Kpvg):** This Cretaceous-age granitic formation locally known as the Paloma Valley Ring Complex constitutes portion of the hills along the northern part of the City and underlies the older alluvium in Area 3 (Northeast I-215 and Clinton Keith Road).

- **Tonalite (map symbol Kpvt):** This Cretaceous-age granitic formation locally known as the Paloma Valley Ring Complex is found along the northeastern part of the City.

- **Metasedimentary Rock (map symbol Trmp/Trmu):** This Mesozoic-aged metamorphic grade marine sedimentary rock unit, locally known as the Bedford Canyon Formation, exists in the northeastern quadrant of the City. This bedrock unit consists of locally folded, laminated to thinly bedded argillite, slate, shale and impure quartzite.

2.3 Site-Specific Geology (Areas 1 through 3)

Based on past experience and review of the referenced reports (Appendix A), the engineering and geologic characteristics of the soils and/or bedrock units within Areas 1 through 3 are further described and summarized as follows:

Area 1 - Southwest Murrieta / Jefferson Business Corridor:

Area 1 is generally underlain by Pauba formation (sandstone-member, Qps) and young alluvial-valley deposits (Qyv) *see Geologic Map – Figure 1*. According to previous site specific reports performed within this area, the following geologic conditions and geotechnical concerns can be summarized:

- The Pauba formation generally consists of brown to light brown, clayey, fine-grained siltstones and silty/clayey, fine- to coarse-grained sandstones (Leighton, 2004 & 2008a, and CHJ, 2007). The Pauba formation in this area is generally considered suitable for support of structures and for use as engineered fill. These soils generally have low Expansion Index (EI<51). However, expansive clay and silt layers may be locally encountered.

- The alluvial-valley deposits are mostly moderately well consolidated, poorly sorted, permeable flood plain deposits consisting of silty sand (SM), poorly-graded to well-graded sand (SP/SW), clayey sand (SC), and sandy clay (CL). Published geologic maps and previous site specific field explorations within this area indicate that the alluvium may exceed 100 feet in depth. The alluvial soils may be susceptible to liquefaction and/or subsidence. The alluvial soils are generally considered suitable for support of structures and for use as engineered fill. These soils generally have low Expansion Index (EI<51). However, expansive clay and silt layers may be locally encountered.

Area 2 - Golden Triangle:

The majority of Area 2 is underlain by the Pauba-sandstone formation (Qps) and conglomerate unit of the Wildomar area (QTws) and localized alluvial-channel deposits (Qya), *see Geologic Map – Figure 1*. According to previous site-specific reports performed within this area, the following geologic/geotechnical conditions can be summarized:

- The Pauba formation consists of brown to light brown, clayey, fine-grained siltstones and silty/clayey, fine- to coarse-grained sandstones (Leighton, 2004 & 2007). The Pauba formation in this area is generally considered suitable for support of structures and for use as engineered fill. These soils generally have low expansion potential (EI<51). However, expansive clay and silt layers may be locally encountered.

- The alluvial-channel deposits consist of unconsolidated to locally poorly consolidated sand and gravel with small amounts of silt. The alluvial soils may be susceptible to liquefaction and/or subsidence and generally not suitable for support of settlement-sensitive structures in their natural state.

Area 3 - Northeast I-215 and Clinton Keith Road:

This northeast development area (Area 3) is primarily underlain by granitic and metamorphic bedrock, *see Geologic Map – Figure 1*. According to previous site-specific reports performed within this area, the following geologic/ geotechnical conditions can be summarized:

- The majority of Area 3 is underlain by Cretaceous-aged granitic bedrock which varies in composition from Monzogranite to Granodiorite (Kpvg) to that of Gabbro (Kgb). The granitic bedrock is locally overlain by a thin veneer of older alluvium (Qvoa). Younger alluvial deposits may also be present locally infilling some surface drainages.

- Based on previous reports in this area (Leighton, 2006 and Kleinfelder, 2007), the condition of the near surface bedrock varies from that of highly disintegrated rock that has weathered becoming soil-like deposits (saprolite) to that of relatively unweathered, hard, very dense, igneous rock. Where exposed, the granitic rocks of monzogranite and granodiorite composition are generally light gray to gray to grayish brown. The gabbroic bedrock observed in this area is generally gray to dark gray.

- The granitic bedrock is generally considered suitable for support of structures and use for engineered fill.

2.4 Groundwater

Based on a review of the referenced reports, groundwater has been encountered less than 10 feet below the existing ground surface along Murrieta Creek. Depth to subsurface water has been reported by the State of California (California Department of Water Resources, 2009) at depths ranging from 21 feet to 100+ feet below ground surface (bgs) in the overall area. However, depending on rainfall and seasonal variation, shallower perched water conditions may exist and typically accumulate within layers of differing permeability, within bedrock fractures and at bedrock/fill contacts. In addition, groundwater seepage can occur in deep cuts in the hills along the northern side of the City as reported during grading of the existing Greer Ranch Residential

development (Leighton, 1999 & 2003). Such conditions are typically mitigated by the placement of subdrains and other appropriate long-term dewatering measures at the time of construction or when the seepage is observed.

2.5 Geologic Hazards

This section discusses the non-earthquake related geologic hazards within the City. The earthquake- or seismically-induced hazards are discussed in Section 3 of this report.

The potential extent and severity of any non-earthquake related geologic hazard varies throughout the General Plan area depending upon the underlying geology, topography, surface soil type, and groundwater conditions. The most common geologic hazards that may be encountered are as follows:

2.5.1 Expansive Soils

Expansive soils are surface deposits rich in clays that expand when wet and shrink when dried. This change in volume can exert detrimental stresses on buildings and cause structural damage. Expansive soils can be widely dispersed and can be found in hillside areas as well as low-lying alluvial basins. There have been reported cases (Leighton, 2004, 2008a) of expansive clay layers within the Pauba formation and Alluvial-Valley deposits.

The site-specific geotechnical reports typically identify the extent of the expansive soils and provide mitigation measures to reduce their impact on the proposed improvements. Such measures may include structural mitigation or ground improvement. The California Building Code contains minimum requirements for construction on expansive soils.

2.5.2 Collapse Soils

The collapse soils phenomenon or "Hydro-consolidation" typically occurs in recently deposited soils (Holocene age - less than 10,000 years old) that were deposited in an arid or semi-arid environment. These soils typically contain a high percentage of voids and possess low relative density. The soil particles may be partially supported by clay or silt, or chemically cemented with carbonates. When inundated by water, these soils collapse and substantial settlement occurs.

Damage to structures and ground cracking due to hydro-consolidation (collapse) of recent alluvial deposits has occurred in the "California Oaks" area of Murrieta (Pacific Soils, 1992). Documented collapsible soils in the Cal Oaks area were determined to be the most severe and resulted in significant property damage. It was discovered that the alluvium was left in place during rough grading, and later collapsed when ground water levels rose significantly due to irrigation or rise in groundwater.

The site-specific geotechnical reports should identify the potential presence of such soils based on laboratory testing and provide mitigation measures to reduce their impact on the proposed improvements. Such measures typically include removing and compacting the collapsible soils.

2.5.3 Loading Settlement

Settlement due to loading can be immediate or occur gradually over a long period of time. Immediate settlement is normally associated with loose granular soils when subjected to loads. Long-term or "consolidation" settlement normally takes place in soft saturated silts and clays. These types of soils are generally found in young alluvium or loosely deposited materials.

Similar to Collapse Soils above, the site-specific geotechnical reports typically identify the potential presence of these materials based on laboratory testing and provide mitigation measures to reduce their impact on the proposed improvements. Such measures typically include removing and compacting the loose or soft soils, surcharging the planned development area or structural mitigation. Structural mitigation may include deep foundation such as piles embedded into underlying dense formation.

2.5.4 Subsidence

Subsidence is the ground settlement that results over time from the extraction of groundwater or oil. This is a phenomenon that usually extends over a large area and occurs on a gradual basis so the settlement effects on a single site, relative to its immediate neighbors, may be negligible as the neighboring properties are also subsiding. However, ground fissuring due to subsidence can cause structural damage and should be evaluated by the site-specific geotechnical report. Although there are no reports of significant subsidence due to groundwater withdrawal in Murrieta, alluvial valley areas are considered susceptible (see Figure 5).

2.5.5 Hazardous Minerals / Radon

Naturally occurring geologic formations throughout California may contain minerals that are considered hazardous. These minerals are Asbestos, Mercury and rocks that contain small amounts of uranium and thorium that decay and release radioactive radon gas.

Radon gas is a naturally occurring radioactive gas that is invisible, tasteless and odorless. Radon gas becomes hazardous when confined in buildings and the long term exposure levels in the air exceed the United States Environmental Protection Agency's (EPA) concentration of 4 picocuries per liter (4pCi/L).

Rocks containing minerals that are known to release radon gas exist in the Murrieta area (CGS, 2009). More information on the risks associated with radon, information on testing and remediation methods can be found at the California Department of Public Health Services website: http://www.cdph.ca.gov/HealthInfo/environhealth/Pages/Radon.

3.0 SEISMICITY AND FAULTING

3.1 General

Murrieta, like the rest of Southern California, is located within a seismically active region as a result of being located near the active margin between the North American and Pacific tectonic plates. Based on published data (Blake 2002), the most significant known active Fault Zones that are capable of seismic ground shaking and can impact the City include:

- *Elsinore Fault Zone:* This fault zone, which includes the local Elsinore-Temecula fault, passes through the City to the west of Interstate I-15 (Figures 2 and 3). The Elsinore-Temecula fault zone is capable of generating a Maximum Earthquake Magnitude (Mw) of 6.8 per the Richter scale.

- *San Jacinto Fault Zone:* This fault zone is located approximately 21 miles northeast of the City and capable of generating earthquakes in excess of 7.1 Mw.

- *Newport-Inglewood Fault Zone (offshore):* This fault zone is located about 28 miles southwest of the City and capable of generating earthquakes in excess of 6.9 Mw.

- *San Andreas Fault Zone (southern section):* This fault zone, located approximately 38 miles northeast of the City, is considered the dominant active fault in California. This fault zone is capable of generating earthquakes in excess of 7.4 Mw.

The Alquist-Priolo Hazards Act (A-P Act) passed by the State legislature in 1972 (renamed the Alquist-Priolo Earthquake Fault Zoning Act in 1994) established earthquake fault zones along faults considered by the State Division of Mines and Geology to be active or potentially active. An active fault is considered one which has experienced surface displacement within the last 11,000 years, while a potentially active fault is a fault which has moved during the past 1.6 million years but proven to have not moved within the past 11,000 years. Such displacement can be recognized by the existence of cliffs in alluvium, terraces, offset stream courses, the alignment of depressions, sag ponds, fault troughs and saddles, and the existence of markedly linear steep mountain fronts. However, some active faults are not visible at the surface and can only be located through detailed subsurface investigations.

The State Geologist designates seismic hazard zones and the State issues earthquake fault zone maps to assist cities and counties in avoiding the hazard of surface fault rupture. The State has identified two Alquist-Priolo Earthquake Fault zones within the City. The Temecula Segment of the Elsinore Fault Zone traverses the City and the Murrieta Creek Fault is located at the extreme southwest corner of the City (See Figure 2 – Alquist-Priolo Earthquake Fault Zone Map). The

earthquake fault zones extend about 500 feet in width on either side of a major active fault trace and about 200 to 300 feet in width on either side of a well defined minor active fault, as designated by the State. Development of a building for human occupancy is generally restricted within 50 feet of an identified fault (Riverside, 2003).

In addition to the State A-P Act mapping, the County of Riverside has zoned fault systems and required similar special studies prior to land development. These are referred to as Riverside County Earthquake Fault Zones (Figure 3).

3.2 Fault Rupture

Faults throughout southern California have formed over millions of years. Some of these faults are generally considered inactive under the present geologic conditions. As indicated above, several State and County Faults systems are mapped within the City boundaries and any proposed tracts of four or more dwelling units or critical structures such as hospitals, schools or emergency structures must investigate the potential for and setback from ground rupture hazards (Riverside County, 2003). This is typically accomplished by excavation of a trench across the site, determining the location of faulting, and establishing building setbacks. Methods for the evaluation of site ground rupture are further presented in the California Geologic Survey Note 49 (CGS, 2002).

In accordance with The Alquist-Priolo Earthquake Fault Zone Act, before a project can be permitted within a fault zone, a geologic investigation must demonstrate that proposed buildings will not be constructed across an A-P or County Fault Zones. A site-specific evaluation and written report must be prepared by a California licensed geologist. If an active fault is found, a structure for human occupancy must be setback 50 feet from the fault unless adequate evidence is presented to support a different setback (Riverside, 2003).

3.3 Ground Shaking

The intensity of earthquake ground shaking varies from one area to another depending primarily upon the distance to the fault, the magnitude of the earthquake, and the local geology. The effect of seismic shaking on future structures or land development projects within the City may be mitigated by adhering to the 2007 California Building Code (CBC) or applicable codes and standards at the time. Site-specific peak and spectral accelerations are to be developed in accordance with Chapter 21 of the 2007 CBC, and the guidelines included in American Society of Civil Engineers Standard 7-05 (ASCE, 2005). For the purpose of illustration, typical seismic design values per the 2007 CBC, Chapter 16, for study Areas 1 through 3 are provided below.

The CBC regulates the design and construction of excavations, foundations, building frames, retaining walls, and other building elements to mitigate the effects of seismic shaking and adverse soil conditions. The procedures and limitations for the design of structures are based on site characteristics, occupancy type, configuration, structural system, height, and seismic zoning.

Area 1- Southwest Murrieta / Jefferson Business Corridor: This area is generally underlain by alluvial deposits and Pauba formation. In accordance with the 2007 CBC, the example site below may be classified as a Class D site, and typical site-specific seismic coefficients are as follows:

Table 1. 2007 CBC Site-Specific Seismic Coefficients – Area 1 Example

CBC Categorization/Coefficient		Acceleration Value (g)
Example Site: Intersection of Guava Street & Jefferson Avenue	Site Latitude (33.5452 N) Site Longitude (-117.1931 W)	
Site Class (Table 1613.5.2) – D		
Mapped Spectral Response Acceleration at 0.2s Period, S_s (Fig. 1613.5(3))		**1.84**
Mapped Spectral Response Acceleration at 1s Period, S_1 (Fig. 1613.5(4))		**0.67**
Short Period Site Coefficient at 0.2s Period, F_a (Table 1613.5.3(1))		1.0
Long Period Site Coefficient at 1s Period, F_v (Table 1613.5.3(2))		1.5
Adjusted Spectral Response Acceleration at 0.2s Period, S_{MS} (Eq. 16-37)		**1.84**
Adjusted Spectral Response Acceleration at 1s Period, S_{M1} (Eq. 16-38)		**1.01**
Design Spectral Response Acceleration at 0.2s Period, S_{DS} (Eq. 16-39)		**1.23**
Design Spectral Response Acceleration at 1s Period, S_{D1} (Eq. 16-40)		**0.67**

* g- Gravity acceleration

Area 2 -Golden Triangle: This area is generally underlain by dense Pauba formation. In accordance with the 2007 CBC, the example site below is classified as a Class D site, and typical site-specific seismic coefficients are as follows.

Table 2. 2007 CBC Site-Specific Seismic Coefficients – Area 2

CBC Categorization/Coefficient		Acceleration Value (g)
Example Site: Intersection of Hancock Avenue and Murrieta Hot Springs Road	Site Latitude (33.5560 N) Site Longitude (-117.1843 W)	
Site Class Definition (Table 1613.5.2) – D		
Mapped Spectral Response Acceleration at 0.2s Period, S_s (Fig. 1613.5(3))		**1.68**
Mapped Spectral Response Acceleration at 1s Period, S_1 (Fig. 1613.5(4))		**0.61**
Short Period Site Coefficient at 0.2s Period, F_a (Table 1613.5.3(1))		1.0
Long Period Site Coefficient at 1s Period, F_v (Table 1613.5.3(2))		1.5
Adjusted Spectral Response Acceleration at 0.2s Period, S_{MS} (Eq. 16-37)		**1.68**
Adjusted Spectral Response Acceleration at 1s Period, S_{M1} (Eq. 16-38)		**0.92**
Design Spectral Response Acceleration at 0.2s Period, S_{DS} (Eq. 16-39)		**1.12**
Design Spectral Response Acceleration at 1s Period, S_{D1} (Eq. 16-40)		**0.61**

* g- Gravity acceleration

Area 3 - Northeast I-215 and Clinton Keith Road: This area is generally underlain by dense granitic rock. In accordance with the 2007 CBC, the example site below is classified as a Class C site, and typical site-specific seismic coefficients are as follows.

Table 3. 2007 CBC Site-Specific Seismic Coefficients – Area 3

CBC Categorization/Coefficient		Acceleration Value (g)
Example Site: Intersection of Baxter Road and Menifee Road	Site Latitude (33.6121 N) Site Longitude (-117.1542 W)	
Site Class Definition (Table 1613.5.2) – C		
Mapped Spectral Response Acceleration at 0.2s Period, S_s (Fig. 1613.5(3))		**1.50**
Mapped Spectral Response Acceleration at 1s Period, S_1 (Fig. 1613.5(4))		**0.60**
Short Period Site Coefficient at 0.2s Period, F_a (Table 1613.5.3(1))		1.0
Long Period Site Coefficient at 1s Period, F_v (Table 1613.5.3(2))		1.3
Adjusted Spectral Response Acceleration at 0.2s Period, S_{MS} (Eq. 16-37)		**1.50**
Adjusted Spectral Response Acceleration at 1s Period, S_{M1} (Eq. 16-38)		**0.78**
Design Spectral Response Acceleration at 0.2s Period, S_{DS} (Eq. 16-39)		**1.00**
Design Spectral Response Acceleration at 1s Period, S_{D1} (Eq. 16-40)		**0.52**

* g- Gravity acceleration

3.4 Secondary Seismic Hazards

Ground shaking can induce "secondary" seismic hazards such as liquefaction and/or lateral spreading, landslides, and subsidence and ground fissuring. Areas of the City known to be at risk from these hazards have been mapped and shown on Figures 4, 5 and 6 (Liquefaction and Subsidence Susceptibility Maps and Seismic Hazard Map, respectfully).

3.4.1 Dynamic Settlement / Liquefaction and "Dry" Settlement

Liquefaction of saturated cohesionless soils can be caused by strong ground motion resulting from earthquakes. Soil liquefaction is a phenomenon in which saturated, cohesionless soils lose their strength due to the build-up of excess pore water pressure during cyclic loading such as that induced by earthquakes. The primary factors affecting the liquefaction potential of deposit are: 1) intensity and duration of earthquake shaking, 2) soil type and relative density, 3) overburden pressures, and 4) depth to groundwater. Soils most susceptible to liquefaction are clean, loose, uniformly graded, fine-grained sands, and non-plastic silts that are saturated. Silty sands, under certain site conditions, may also be susceptible to liquefaction. As depicted on Figure 4, most of the alluvial deposits along the Murrieta Creek lie within liquefaction hazard zone per County of Riverside. Most of these alluvial soils are also considered susceptible to liquefaction per State Seismic Hazard Zones (Figure 6). Future development within these areas, require a site-specific evaluation for liquefaction hazard.

In addition to liquefaction settlement, dynamic densification of "dry" or moist soil above the water table can occur. The site-specific evaluation for future development should also include evaluation for settlement associated with dynamic densification of "dry" soils. To reduce the effects and magnitude of seismically-induced dynamic settlements, remedial grading measures or ground improvement techniques are normally implemented.

3.4.2 Lateral Spreading

The phenomenon of liquefaction may also produce lateral spreading of soils adjacent to a body of water or water course (Murrieta Creek and Warm Springs Creek). Lateral spreading is therefore considered as a liquefaction-induced ground failure whereby block(s) of surficial intact natural or artificial fill soils displace laterally downslope or towards a free face along a shear zone that has formed within the liquefied sediment (Bartlett and Youd, 1995). The displacement of the ground surface associated with this lateral spreading may be on the order of several inches to several feet at the top of the slope and may affect areas well beyond the top-of-slope. Developments located further from the creeks or drainage courses are anticipated to be at less risk from lateral spreading that those adjacent to the creek embankment. Detailed analyses of lateral spreading affects to properties adjacent to creeks and drainages should be performed by

the geotechnical consultant on a site-by-site basis. To reduce the effects or magnitude of lateral spreading, remedial grading measures on ground improvement techniques are normally implemented.

3.4.3 Differential Subsidence and Ground Fissuring

Ground fissuring typically develops along previous established planes of weakness such as active and possibly potentially active fault traces as well as along steep buried contacts between bedrock to recent alluvial soils. The active Elsinore-Temecula and the Murrieta Creek fault may develop fissuring along the fault trace during a significant seismic event or groundwater elevation change. As such, there is a low to high potential for ground fissuring and associated differential subsidence along the active fault zones. If commercial water wells are installed within or near the subsidence zone, the potential for ground fissuring and differential settlement could be substantially increased.

3.4.4 Seiches and Tsunamis

A seiche is an oscillation of a landlocked body of water that can cause water damage to buildings, roads, and infrastructure that surround the body of water. Due to the distance to existing large bodies of water (i.e. Diamond Valley Lake, Lake Skinner, Lake Elsinore, etc.), it is expected that such hazard should not be a concern for structures within the City.

A tsunami is a great ocean wave produced by submarine earth movement or volcanic eruption. The City is more than 20 miles from the Pacific Ocean. Therefore, the potential for tsunamis is nonexistent.

3.4.5 Flooding

Portions of the City lie within the boundaries of the FEMA 100-year flood plain. Potential flood hazard should be evaluated on a case-by-case basis during individual site developments. Flooding could also occur along the Warm Springs Creek due to potential breach of any of dams associated with Diamond Valley Lake and Lake Skinner. This report does not address such flood hazard risk.

3.4.6 Landslides

The potential for earthquake related landsliding within the City limits is based on known conditions and published geologic maps. Several Old landslides have been mapped in some areas along the Santa Ana Mountains eastern slopes and the hills along the northern side of the City. The State Seismic Hazard Zones (CGS, 2007) provides locations of previous known landsliding or where local conditions indicate a potential for ground displacements (see Figure 6). Site-specific geologic review should be performed to

determine whether the potential for landsliding or slope instability exists and whether buttressing or other slope stabilization methods or avoidance are required.

3.4.7 Rock Fall Hazards

The potential for rock fall due to natural weathering and instability or rock falls due to a seismic event are possible in local areas of the City. The hazard areas are limited to those properties at the base of hill sides where rocks and boulders exist. Site-specific geologic review should be performed to evaluate such hazard and provide appropriate corrective measures. To reduce the potential effects from rock falls in these areas, mitigation may include avoidance, rock removal, anchoring or catchment devises.

4.0 GRADING AND DESIGN CONSIDERATIONS

4.1 General

Future land development within the City should be evaluated on a site-specific (or individual project) basis to address the potential hazards outlined in this report. The following sections discuss typical grading concerns and provide general criteria for earthwork construction based on past experience in the City and in accordance with current standard of care in this locality.

4.2 Grading and Earthwork Considerations

Grading and earthwork construction for future land development within the City should conform to the latest edition of the CBC and City and/or County grading ordinances. The General Earthwork and Grading Specifications presented in this report (Appendix B) are provided for typical grading projects in this locality and may be used for future developments provided they are reviewed and found applicable by the geotechnical consultant of the specific development(s).

4.2.1 Site Preparation

Prior to any site grading, the contractor should clear any surface and subsurface obstructions, including debris, abandoned improvements and heavy vegetation. Holes resulting from removal of buried obstructions, which extend below the depth of removal based on site-specific study, should be filled with properly compacted soil. Existing wells, septic tanks and associated utilities should be abandoned and cleared in accordance with City and County guidelines.

4.2.2 Remedial Grading

Remedial grading requirements for any given site are determined based on a site-specific geotechnical investigation to provide stable ground for the proposed development or structures. Generally, the upper weathered formational materials or loose soils are removed until dense, relatively "non-compressible" soils (alluvium or Formation materials) are encountered. This remedial removal will typically reduce the adverse impact of the static or dynamic settlements on settlement-sensitive structures. Based on past experience and review of the references included in Appendix A, the following remedial grading should be anticipated within the following specific three areas:

Area 1- Southwest Murrieta / Jefferson Business Corridor:

This area is generally underlain by Pauba formation (sandstone-member) and young alluvial-valley and –channel deposits as well as undocumented fill soils. For planning

purposes, the following general remedial grading should be anticipated beneath settlement-sensitive structures including slopes and pavement:

- *Undocumented fill:* typically all removed and recompacted provided these soils are suitable for reuse as engineered fill.
- *Alluvial-channel deposits*: typically all removed and recompacted provided depth is less than 10 to 20 feet. Deeper alluvium in some locations may be left in place provided it is found suitable by the geotechnical consultant.
- *Alluvial-valley deposits*: typically the upper 5 to 10 feet are removed and recompacted. Deeper alluvium is generally left in place provided it is found suitable by the geotechnical consultant and/or improved in place.
- *Pauba formation*: typically the upper 2 to 5 feet are removed and recompacted. Deeper soil is generally left in place provided it is found suitable by the geotechnical consultant against collapse potential or slope instability.

Area 2 -Golden Triangle:

This area is generally underlain by Pauba formation (sandstone-member) and young–channel deposits as well as potential undocumented fill soils. In general, the following remedial grading should be anticipated beneath settlement-sensitive structures including slopes and pavement:

- *Undocumented fill:* typically all removed and recompacted provided these soils are suitable for reuse as engineered fill.
- *Alluvial-channel deposits*: typically all removed and recompacted provided depth is less than 10 to 20 feet. Deeper alluvium in some locations may be left in place provided it is found suitable by the geotechnical consultant.
- *Pauba formation*: typically the upper 2 to 5 feet are removed and recompacted. Deeper soil is generally left in place provided it is found suitable by the geotechnical consultant against collapse potential or slope instability.

Area 3 - Northeast I-215 and Clinton Keith Road:

This area is generally underlain by granitic bedrock covered with a relatively thin veneer of older and/or younger alluvial deposits. In general, the following remedial grading should be anticipated beneath settlement-sensitive structures including slopes and pavement:

- *Undocumented fill:* If encountered, all removed and recompacted provided suitable for reuse as engineered fill.

- *Alluvial deposits*: typically all removed and recompacted if depth is less than 5 to 10 feet. Deeper alluvium may be left in place provided found it is found suitable by the geotechnical consultant.
- *Granitic Rock:* typically suitable for foundation support. However, in order to mitigate the potential adverse affects of differential settlement, cut/fill transition subgrade for foundations is normally over-excavated within the cut portion by a minimum depth of 3 feet or one-half of the maximum fill thickness over a certain distance. In addition, such hard rock is over-excavated to a depth of 3 feet below finish grades during mass grading in order to facilitate excavation of footings and utility trenches.
- Based on seismic refraction survey and other rock hardness studies (Leighton, 2006), the granitic bedrock in this area is expected to rippable to depths of approximately 15-25 feet below existing grades utilizing a Caterpillar D9R Tracked Dozer or equivalent. Excavations or grading using conventional earthmoving equipment below 15 to 25 feet of ground surface or within localized areas of elevated resistant rock/boulders will likely be difficult and require blasting or other rock reducing techniques.
- Due to the presence of shallow resistant bedrock, oversize materials may be generated during grading or construction sites that require relatively deep cuts. Oversize materials are generally not suitable to be used as fill and may require special handling and grading procedures.
- Severely weathered bedrock is considered unsuitable for support of engineered fill loads and/or improvements in its current state and should be removed and replaced as compacted fill. Moderately to slightly weathered bedrock may be considered suitable for the support of artificial fills or other structural improvements.

4.2.3 Suitability of Native Soils for Fills

Topsoil and vegetation layers, root zones, and similar surface materials are typically not suitable for re-use as engineered fill and normally striped and stockpiled for either re-use in landscape areas or removed from the site. Most alluvial materials, Pauba formation and granitic bedrock are considered suitable for re-use as compacted engineered fills. However, excavations in the granitic rock in Area 3 may generate oversize materials that are generally not suitable to be used as engineered fill. Typically, cobbles and boulders larger than 6-inches in diameter are not placed in structural fill under settlement-sensitive improvements and may require special handling and grading procedures.

4.2.4 Shrinkage and Bulking Considerations

The volume change of excavated native soils upon compaction is expected to vary with materials, density, insitu moisture content, location and compaction effort. The in-place

and compacted densities of soil materials vary and accurate overall determination of shrinkage and bulking normally cannot be made. Therefore, a balance area or ability to adjust grades slightly to accommodate some variation should be evaluated on a site-specific basis. Based on past experience, the following should be anticipated during future grading:

- Topsoil and loose-reusable Fill: 10 to 30 percent shrinkage
- Alluvium and Colluvium 10 to 20 percent shrinkage
- Pauba Formation: 10 percent bulking to 10 percent shrinkage.
- Granitic Rock: 5 to 15 percent bulking

4.3 Foundation Design

The following foundation systems have been commonly used in the past within the General Plan area to support buildings and infrastructure projects. The most suitable and economical foundation system for any given structure should be selected based site-specific geotechnical evaluation.

Conventional Spread and Continuous Wall Footings:
This shallow foundation type is generally the most economical when near surface soils conditions provide an adequate support for the anticipated structural loads. For footings founded on newly placed properly compacted fill soil or dense formational materials, an allowable vertical bearing capacity of 2,000 pounds-per-square-foot (psf) is typically used. This allowable bearing pressure may be increased with embedment and/or width, based on a site-specific evaluation.

Driven Pile Foundations
Structures underlain by liquefiable, compressible, or collapsible soils that have a potential to exceed standards for conventional foundations may be supported by pile foundations, which should extend to competent or dense formational materials as determined by the geotechnical consultant.

Drilled Pile (Caissons) Foundations
As an alternative to driven piles, drilled cast-in-place piles may be considered to mitigate static or dynamic settlement conditions. However, if relatively loose soils and relatively high ground water table is encountered, the excavation of the drilled piers may be difficult due to caving soils or heaving sands.

Mat Foundation

A concrete mat-type foundation appropriately reinforced may reduce the effects caused by differential settlement. If this foundation system is utilized, the remedial removal earthwork may be minimized based on a site-specific geotechnical investigation. Stiff mat-type foundations, if used, will not preclude the tilt of the foundation due to compression within natural or artificial fills (static or dynamic).

4.4 Soil Corrosivity and Sulfate Attack

Based on review of existing soils reports, the different soils units within the General Plan area are considered corrosive to exposed metal improvements, such as buried conduit or strap-type building to foundation seismic tiedowns.

Corrosion testing should be performed on site-specific basis to confirm the corrosivity characteristics of the onsite soils. Concrete foundations in contact with site soils should be designed in accordance with applicable provisions of the California Building Code. A qualified corrosion engineer should be consulted to provide recommendations for protection of buried metal improvements.

5.0 SITE-SPECIFIC STUDIES

5.1 Geotechnical / Geologic Evaluation

Site-specific geotechnical evaluations should be performed to address the geologic and seismic concerns and provide recommendations to mitigate for such potential hazards as outlined in this report. The geotechnical evaluation should include a review of published geologic maps, aerial photographs, site-specific field explorations (borings and/or trenches), and appropriate laboratory testing on representative soils samples to generate basis for site grading, foundation design and mitigative measures. The State of California has prepared guidelines for the evaluation and mitigation of seismic hazards (http://www.conservation.ca.gov/cgs/shzp/webdocs/Documents/sp117.pdf).

5.2 Fault Investigation

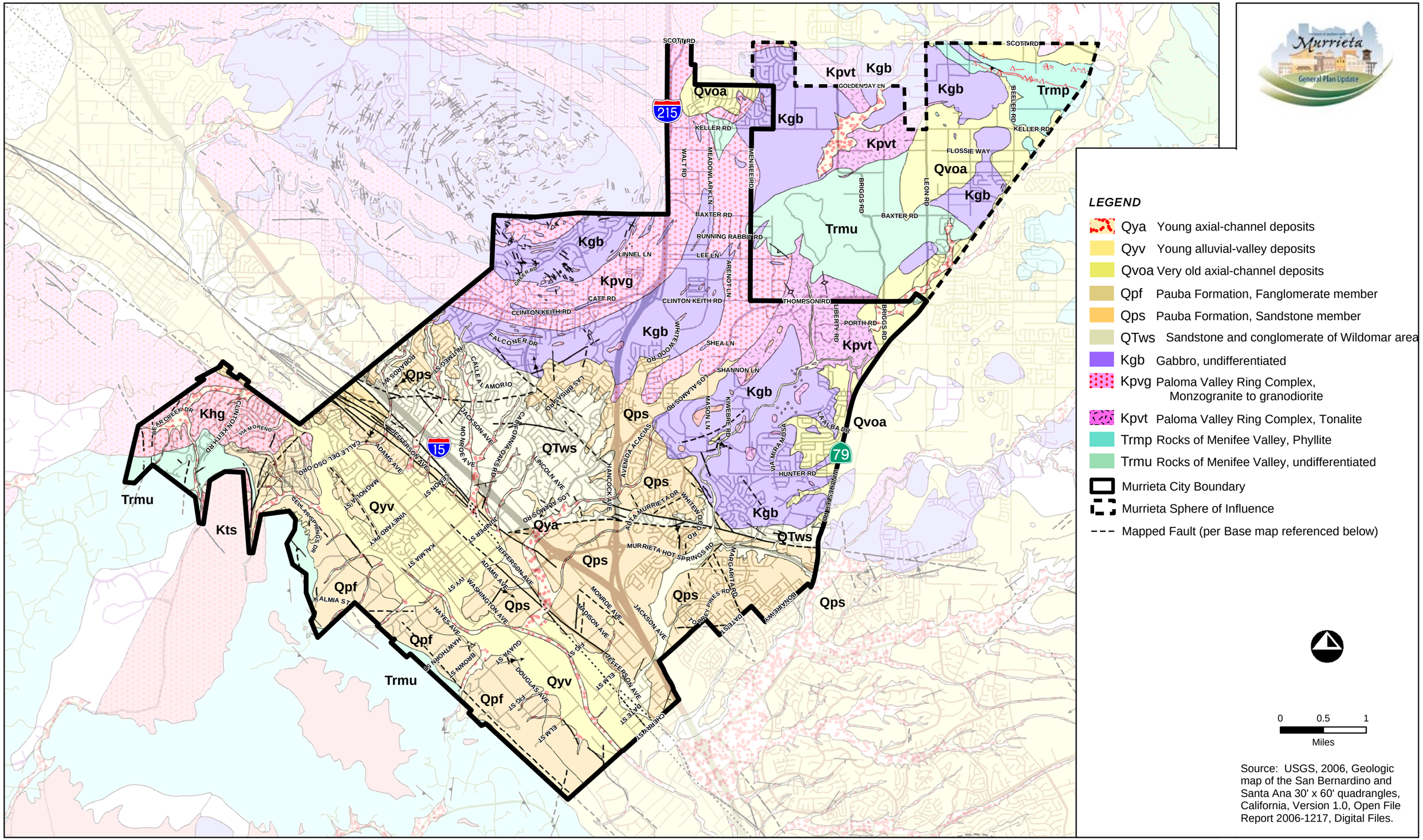
As indicated in previous sections of this report, site-specific fault investigation with respect to development located within the mapped Fault Zones (Exhibits 2 and 3) should be completed as necessary. However, fault investigations within other parts of the City may also be deemed necessary by the geologic consultant. The location of the fault(s) should be determined within the project site in order to establish fault setback recommendations for buildings/structures as per State guidelines. The location(s) of active faults and recommended structure setbacks limits should be surveyed and presented on the site development plan prepared by the project civil engineer. The State of California has prepared guidelines for the evaluation of surface fault rupture (http://www.conservation.ca.gov/cgs/information/publications/cgsnotes/note49/Documents/note49.pdf).

6.0 LIMITATIONS

This report was prepared solely for RBF Consulting on behalf of the City of Murrieta and their design team, solely for their preparation of the General Plan Update. This report was prepared in accordance with generally accepted geologic and geotechnical engineering practices at this time in California. No warranty is expressed or implied.

This report was necessarily based in part upon data obtained from a review of available reports, analyses, histories of occurrences, and limited information on historical events and observations. Such information is necessarily incomplete. It is understood that site-specific subsurface geotechnical data is necessary for future developments. The nature of many sites is such that differing characteristics can be experienced within small distances and under various climatic conditions. Changes in subsurface conditions can, and do, occur over time.

This report is not authorized for use by, and is not to be relied upon by any party except, RBF Consulting on behalf of the City of Murrieta with whom Leighton Consulting, Inc. has contracted for the work. Use of or reliance on this report by any other party is at that party's risk. Unauthorized use of or reliance on this report constitutes an agreement to defend and indemnify Leighton Consulting, Inc. from and against any liability which may arise as a result of such use or reliance, regardless of any fault, negligence, or strict liability of Leighton Consulting, Inc.

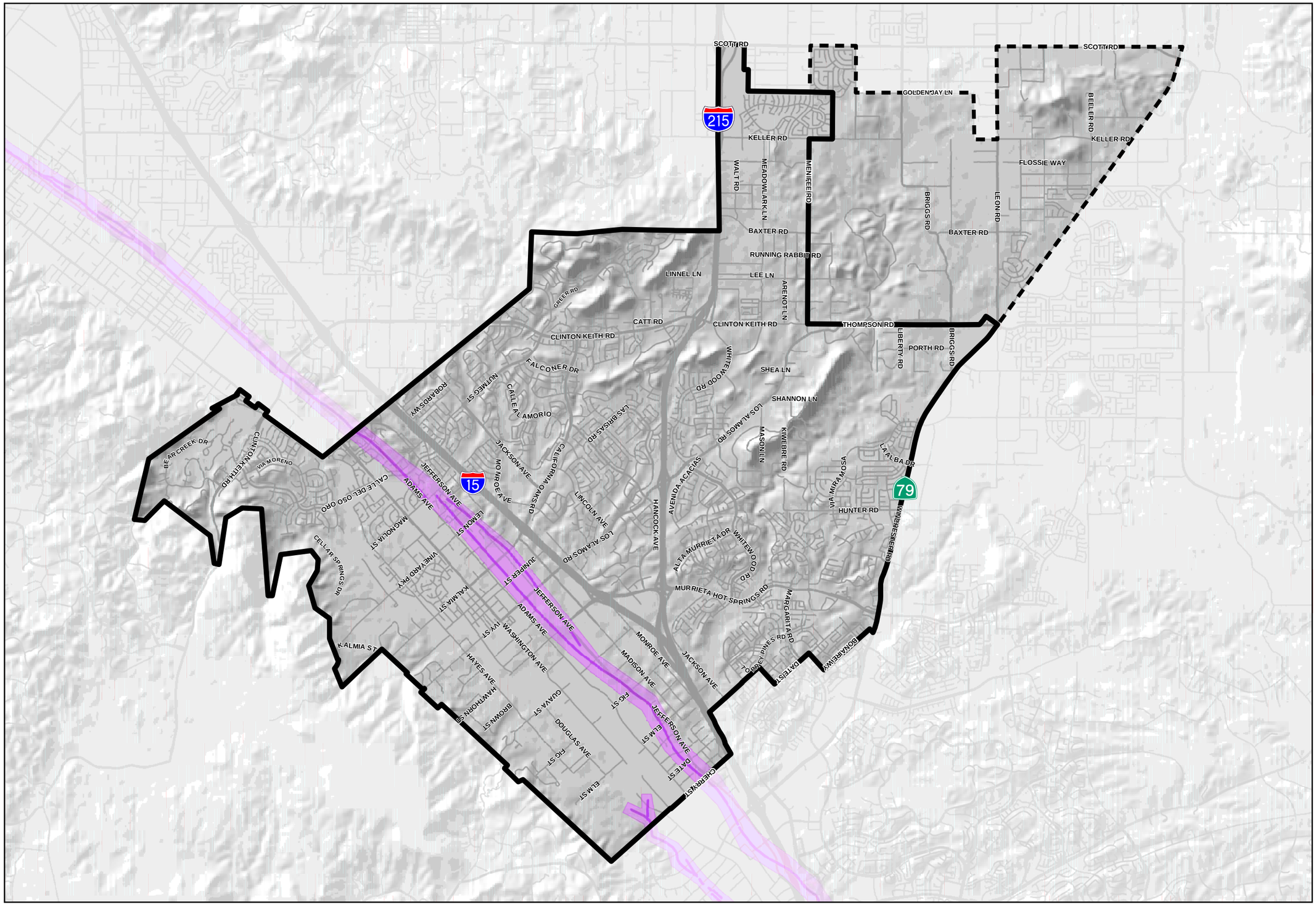


Project: 602728-001

January 2010

Regional Geology Map

Figure 1



Murrieta General Plan Update

LEGEND

Alquist-Priolo Earthquake Faults

Alquist-Priolo Earthquake Fault Zones

Murrieta City Boundary

Murrieta City Sphere of Influence

0 0.5 1

Miles

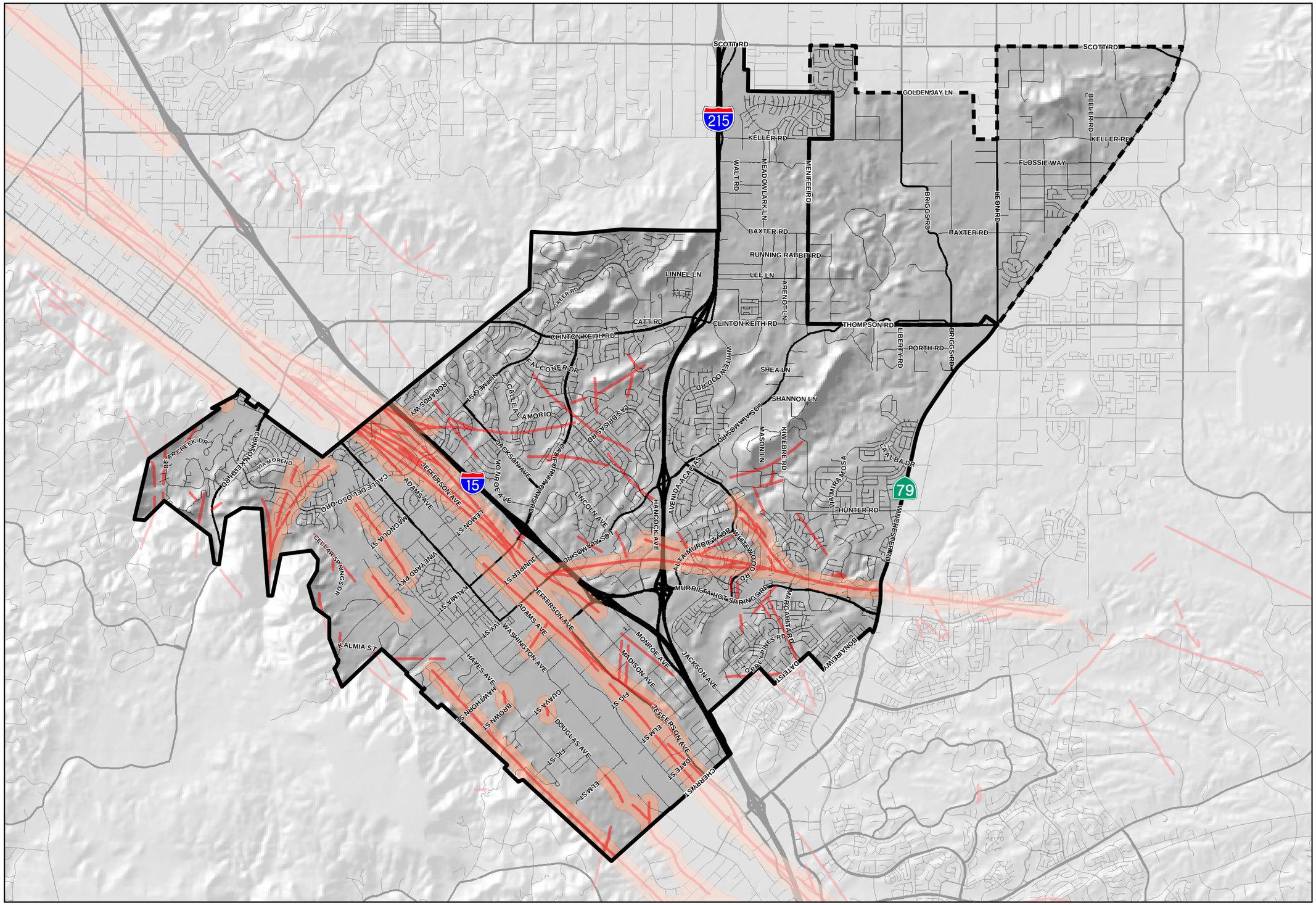
Source: CGS, 2002, State of California Alquist Priolo Fault Zones and Faults, Digital Files

Project: 602728-001

January 2010

Alquist-Priolo Earthquake Fault Zone Map

Figure 2



LEGEND

- Riverside County Earthquake Faults
- Riverside County Earthquake Fault Zones
- Murrieta City Boundary
- Murrieta City Sphere of Influence

0 0.5 1
Miles

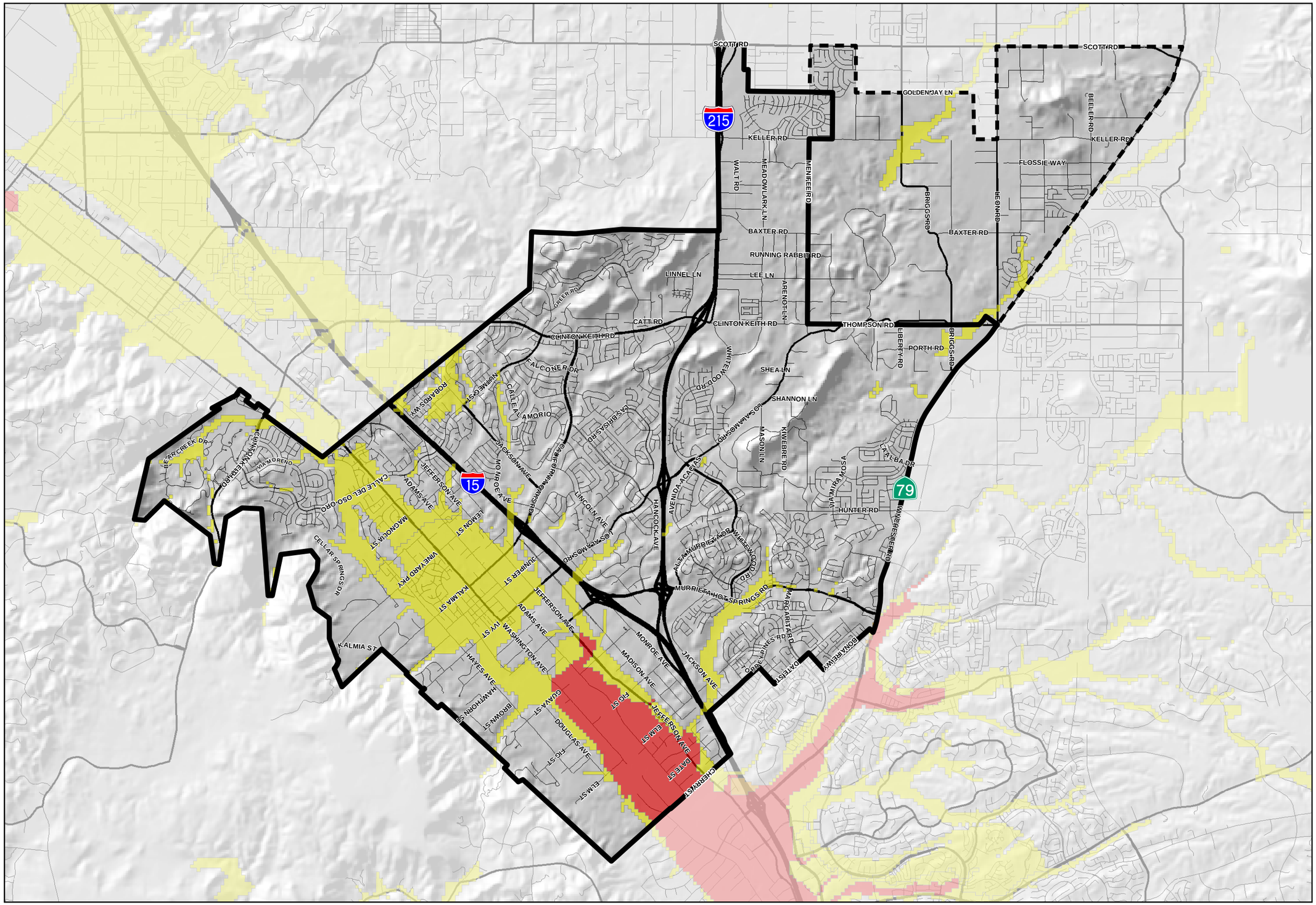
Source: Riverside County Earthquake Fault Zones and Faults; Digital Files

Project: 602728-001

January 2010

Fault Hazard Map per Riverside County

Figure 3



LEGEND

Liquefaction Susceptability

- Very High
- High
- Moderate

- Murrieta City Boundary
- Murrieta City Sphere of Influence

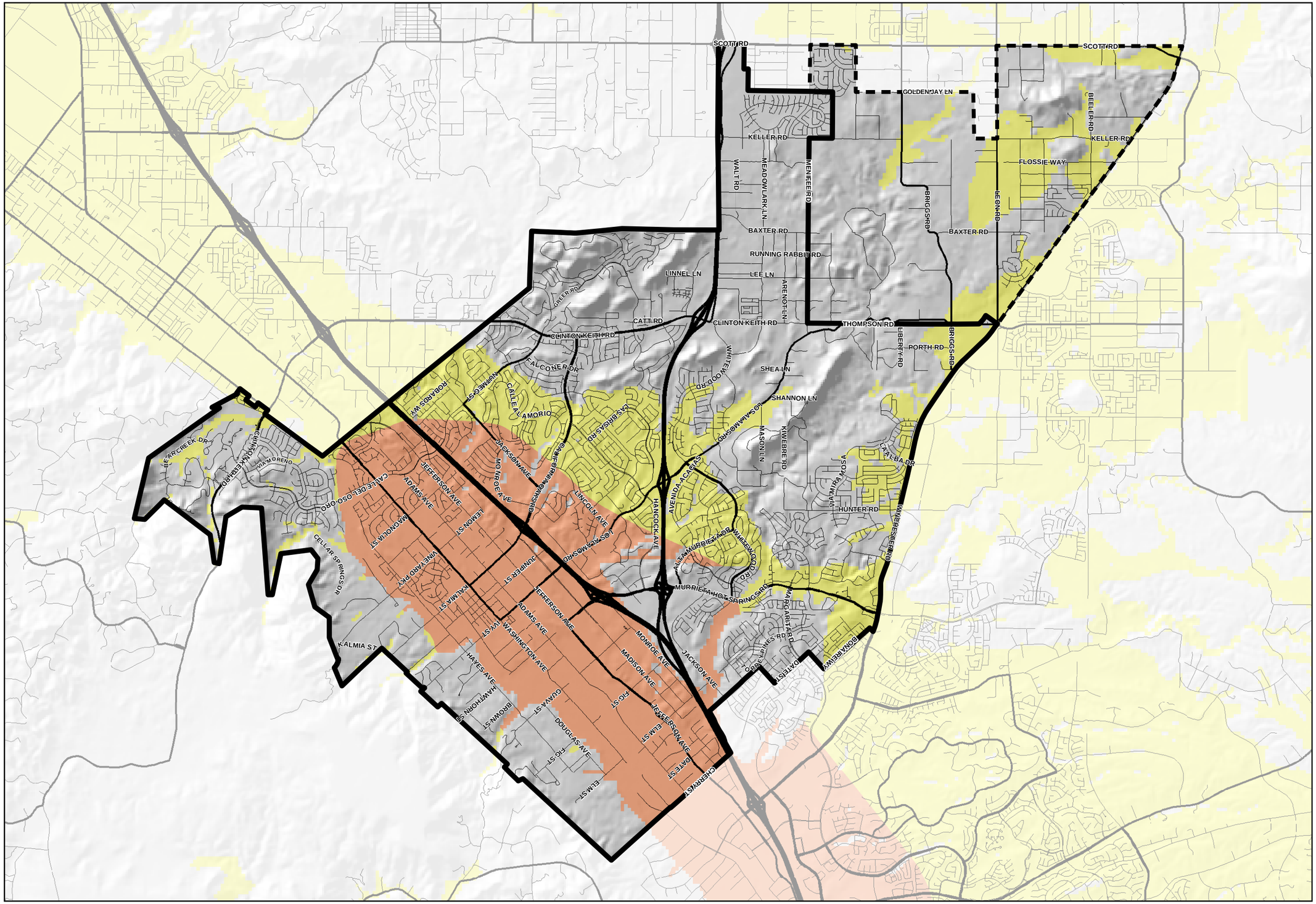
0 0.5 1
Miles

Source: Riverside County, 2006, Liquefaction Susceptibility Data, Digital Files

Project: 602728-001
January 2010

Liquefaction Suceptibility Map Per Riverside County

Figure 4



LEGEND

Subsidence Susceptibility

- Active
- Susceptible

- Murrieta City Boundary
- Murrieta City Sphere of Influence

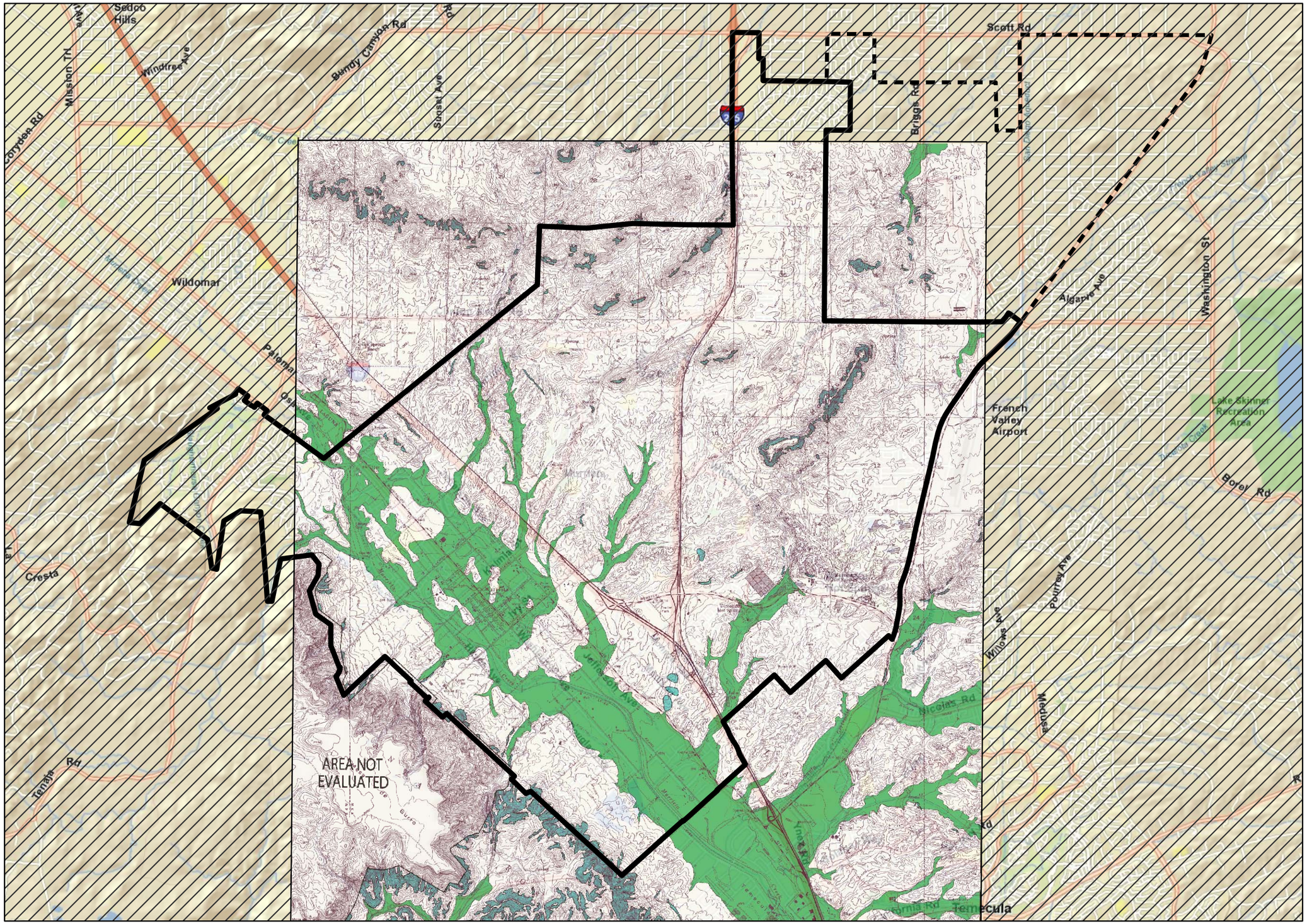
0 0.5 1
Miles

Source: Riverside County, 2007, Subsidence Data.

Project: 602728-001
January 2010

Subsidence Susceptibility Map per Riverside County

Figure 5



Murrieta General Plan Update

Legend

Murrieta City Sphere of Influence

Murrieta City Boundary

Area with

Liquefaction Potential

Earthquake Induced Landslide

CGS Data Not Available

0 0.5 1 Miles

Basemap: ESRI Resource Center Maps, January 2010.
Thematic Layer Source: Digital Scan of CGS Seismic Hazard Zones Map, Murrieta Quadrangle, December 5, 2007

Project: 602728-001

January 2010

State Seismic Hazard Zones Map

Figure 6

APPENDIX A

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Aerial Photographs Reviewed

Flight Date	Source	Photograph No.	Scale
3/11/48	USAF	102A, 104A	1:11,300
8/28/53	USDA	AXN – 2K:37-41 57-60, 132, 133, 149-151	1:20,000
5/9/61	RCFCD	4-7	1:12,000
1/28/62	RCFCD	18, 19	1:24,000
1/28/62	RCFCD	1-66, 1-67	1:24,000
1/30/62	RCFCD	3-409, 3-410	1:24,000
9/16/64	RCFCD	1-12, 14-20, 38-40	1:12,000
9/30/64	RCFCD	36-38, 49, 50	1:12,000
11/23/64	RCFCD	70-72, 77-80	1:12,000
5/16/68	RCFCD	14-16, 22-25	1:12,000
6/25/68	RCFCD	1, 2	1:24.000
2/20/72	RCFCD	30-32, 41-43	1:12,000
6/20/74	RCFCD	726, 728-733, 803-808, 874-877, 956, 957	1:24,000
1/27/78	RCFCD	43-45	1:6,000
5/4/80	RCFCD	759, 760, 833, 834, 980, 982, 983	1:24,000
2/28/80	RCFCD	3-7, 20, 21	1:6,000
12/8/83	RCFCD	360-362, 393-399	1:19,200
12/15/83	RCFCD	555-558, 587-589	1:19,200
1/25/90	RCFCD	15-90, 15-20	1:19,800

APPENDIX B

GENERAL SPECIFICATIONS FOR ROUGH GRADING

LEIGHTON CONSULTING, INC

GENERAL EARTHWORK AND GRADING SPECIFICATIONS FOR ROUGH GRADING

1.0 General

1.1 Intent: These General Earthwork and Grading Specifications are for the grading and earthwork shown on the approved grading plan(s) and/or indicated in the geotechnical report(s). These Specifications are a part of the recommendations contained in the geotechnical report(s). In case of conflict, the specific recommendations in the geotechnical report shall supersede these more general Specifications. Observations of the earthwork by the project Geotechnical Consultant during the course of grading may result in new or revised recommendations that could supersede these specifications or the recommendations in the geotechnical report(s).

1.2 The Geotechnical Consultant of Record: Prior to commencement of work, the owner shall employ the Geotechnical Consultant of Record (Geotechnical Consultant). The Geotechnical Consultants shall be responsible for reviewing the approved geotechnical report(s) and accepting the adequacy of the preliminary geotechnical findings, conclusions, and recommendations prior to the commencement of the grading.

Prior to commencement of grading, the Geotechnical Consultant shall review the "work plan" prepared by the Earthwork Contractor (Contractor) and schedule sufficient personnel to perform the appropriate level of observation, mapping, and compaction testing.

During the grading and earthwork operations, the Geotechnical Consultant shall observe, map, and document the subsurface exposures to verify the geotechnical design assumptions. If the observed conditions are found to be significantly different than the interpreted assumptions during the design phase, the Geotechnical Consultant shall inform the owner, recommend appropriate changes in design to accommodate the observed conditions, and notify the review agency where required. Subsurface areas to be geotechnically observed, mapped, elevations recorded, and/or tested include natural ground after it has been cleared for receiving fill but before fill is placed, bottoms of all "remedial removal" areas, all key bottoms, and benches made on sloping ground to receive fill.

The Geotechnical Consultant shall observe the moisture-conditioning and processing of the subgrade and fill materials and perform relative compaction testing of fill to determine the attained level of compaction. The Geotechnical Consultant shall provide the test results to the owner and the Contractor on a routine and frequent basis.

1.3 The Earthwork Contractor: The Earthwork Contractor (Contractor) shall be qualified, experienced, and knowledgeable in earthwork logistics, preparation and processing of ground to receive fill, moisture-conditioning and processing of fill, and compacting fill. The Contractor shall review and accept the plans, geotechnical report(s), and these Specifications prior to commencement of grading. The Contractor shall be solely responsible for performing the grading in accordance with the plans and specifications.
The Contractor shall prepare and submit to the owner and the Geotechnical Consultant a work plan that indicates the sequence of earthwork grading, the number of "spreads" of

work and the estimated quantities of daily earthwork contemplated for the site prior to commencement of grading. The Contractor shall inform the owner and the Geotechnical Consultant of changes in work schedules and updates to the work plan at least 24 hours in advance of such changes so that appropriate observations and tests can be planned and accomplished. The Contractor shall not assume that the Geotechnical Consultant is aware of all grading operations.

The Contractor shall have the sole responsibility to provide adequate equipment and methods to accomplish the earthwork in accordance with the applicable grading codes and agency ordinances, these Specifications, and the recommendations in the approved geotechnical report(s) and grading plan(s). If, in the opinion of the Geotechnical Consultant, unsatisfactory conditions, such as unsuitable soil, improper moisture condition, inadequate compaction, insufficient buttress key size, adverse weather, etc., are resulting in a quality of work less than required in these specifications, the Geotechnical Consultant shall reject the work and may recommend to the owner that construction be stopped until the conditions are rectified.

2.0 Preparation of Areas to be Filled

2.1 Clearing and Grubbing: Vegetation, such as brush, grass, roots, and other deleterious material shall be sufficiently removed and properly disposed of in a method acceptable to the owner, governing agencies, and the Geotechnical Consultant.

The Geotechnical Consultant shall evaluate the extent of these removals depending on specific site conditions. Earth fill material shall not contain more than 1 percent of organic materials (by volume). No fill lift shall contain more than 5 percent of organic matter. Nesting of the organic materials shall not be allowed.

If potentially hazardous materials are encountered, the Contractor shall stop work in the affected area, and a hazardous material specialist shall be informed immediately for proper evaluation and handling of these materials prior to continuing to work in that area.

As presently defined by the State of California, most refined petroleum products (gasoline, diesel fuel, motor oil, grease, coolant, etc.) have chemical constituents that are considered to be hazardous waste. As such, the indiscriminate dumping or spillage of these fluids onto the ground may constitute a misdemeanor, punishable by fines and/or imprisonment, and shall not be allowed.

2.2 Processing: Existing ground that has been declared satisfactory for support of fill by the Geotechnical Consultant shall be scarified to a minimum depth of 6 inches. Existing ground that is not satisfactory shall be overexcavated as specified in the following section. Scarification shall continue until soils are broken down and free of large clay lumps or clods and the working surface is reasonably uniform, flat, and free of uneven features that would inhibit uniform compaction.

2.3 Overexcavation: In addition to removals and overexcavations recommended in the approved geotechnical report(s) and the grading plan, soft, loose, dry, saturated, spongy, organic-rich, highly fractured or otherwise unsuitable ground shall be overexcavated to competent ground as evaluated by the Geotechnical Consultant during grading.

2.4 Benching: Where fills are to be placed on ground with slopes steeper than 5:1 (horizontal to vertical units), the ground shall be stepped or benched. Please see the Standard Details for a graphic illustration. The lowest bench or key shall be a minimum of 15 feet wide and at least 2 feet deep, into competent material as evaluated by the Geotechnical Consultant. Other benches shall be excavated a minimum height of 4 feet into competent material or as otherwise recommended by the Geotechnical Consultant. Fill placed on ground sloping flatter than 5:1 shall also be benched or otherwise overexcavated to provide a flat subgrade for the fill.

2.5 Evaluation/Acceptance of Fill Areas: All areas to receive fill, including removal and processed areas, key bottoms, and benches, shall be observed, mapped, elevations recorded, and/or tested prior to being accepted by the Geotechnical Consultant as suitable to receive fill. The Contractor shall obtain a written acceptance from the Geotechnical Consultant prior to fill placement. A licensed surveyor shall provide the survey control for determining elevations of processed areas, keys, and benches.

3.0 Fill Material

3.1 General: Material to be used as fill shall be essentially free of organic matter and other deleterious substances evaluated and accepted by the Geotechnical Consultant prior to placement. Soils of poor quality, such as those with unacceptable gradation, high expansion potential, or low strength shall be placed in areas acceptable to the Geotechnical Consultant or mixed with other soils to achieve satisfactory fill material.

3.2 Oversize: Oversize material defined as rock, or other irreducible material with a maximum dimension greater than 8 inches, shall not be buried or placed in fill unless location, materials, and placement methods are specifically accepted by the Geotechnical Consultant. Placement operations shall be such that nesting of oversized material does not occur and such that oversize material is completely surrounded by compacted or densified fill. Oversize material shall not be placed within 10 vertical feet of finish grade or within 2 feet of future utilities or underground construction.

3.3 Import: If importing of fill material is required for grading, proposed import material shall

meet the requirements of Section 3.1. The potential import source shall be given to the Geotechnical Consultant at least 48 hours (2 working days) before importing begins so that its suitability can be determined and appropriate tests performed. Import fill should be free of all deleterious material and hazardous waste. Testing for hazardous waste typically takes between 7 and 14 working days.

4.0 Fill Placement and Compaction

4.1 Fill Layers: Approved fill material shall be placed in areas prepared to receive fill (per Section 3.0) in near-horizontal layers not exceeding 8 inches in loose thickness. The Geotechnical Consultant may accept thicker layers if testing indicates the grading procedures can adequately compact the thicker layers. Each layer shall be spread evenly and mixed thoroughly to attain relative uniformity of material and moisture throughout.

4.2 Fill Moisture Conditioning: Fill soils shall be watered, dried back, blended, and/or mixed, as necessary to attain a relatively uniform moisture content at or slightly over optimum. Maximum density and optimum soil moisture content tests shall be performed in accordance with the American Society of Testing and Materials (ASTM Test Method D1557-91).

4.3 Compaction of Fill: After each layer has been moisture-conditioned, mixed, and evenly spread, it shall be uniformly compacted to not less than 90 percent of maximum dry density (ASTM Test Method D1557-91). Compaction equipment shall be adequately sized and be either specifically designed for soil compaction or of proven reliability to efficiently achieve the specified level of compaction with uniformity.

4.4 Compaction of Fill Slopes: In addition to normal compaction procedures specified above, compaction of slopes shall be accomplished by backrolling of slopes with sheepsfoot rollers at increments of 3 to 4 feet in fill elevation, or by other methods producing satisfactory results acceptable to the Geotechnical Consultant. Upon completion of grading, relative compaction of the fill, out to the slope face, shall be at least 90 percent of maximum density per ASTM Test Method D1557-91.

4.5 Compaction Testing: Field tests for moisture content and relative compaction of the fill soils shall be performed by the Geotechnical Consultant. Location and frequency of tests shall be at the Consultant's discretion based on field conditions encountered. Compaction test locations will not necessarily be selected on a random basis. Test locations shall be selected to verify adequacy of compaction levels in areas that are judged to be prone to inadequate compaction (such as close to slope faces and at the fill/bedrock benches).

4.6 Frequency of Compaction Testing: Tests shall be taken at intervals not exceeding 2 feet in vertical rise and/or 1,000 cubic yards of compacted fill soils embankment. In addition, as a guideline, at least one test shall be taken on slope faces for each 5,000 square feet of slope face and/or each 10 feet of vertical height of slope. The Contractor shall assure that fill construction is such that the testing schedule can be accomplished by the Geotechnical Consultant. The Contractor shall stop or slow down the earthwork construction if these minimum standards are not met.

4.7 Compaction Test Locations: The Geotechnical Consultant shall document the approximate elevation and horizontal coordinates of each test location. The Contractor shall coordinate with the project surveyor to assure that sufficient grade stakes are established so that the Geotechnical Consultant can determine the test locations with sufficient accuracy. At a minimum, two grade stakes within a horizontal distance of 100 feet and vertically less than 5 feet apart from potential test locations shall be provided.

5.0 Subdrain Installation

Subdrain systems shall be installed in accordance with the approved geotechnical report(s), the grading plan, and the Standard Details. The Geotechnical Consultant may recommend additional subdrains and/or changes in subdrain extent, location, grade, or material depending on conditions encountered during grading. All subdrains shall be surveyed by a land surveyor/civil engineer for line and grade after installation and prior to burial. Sufficient time should be allowed by the Contractor for these surveys.

6.0 Excavation

Excavations, as well as over-excavation for remedial purposes, shall be evaluated by the Geotechnical Consultant during grading. Remedial removal depths shown on geotechnical plans are estimates only. The actual extent of removal shall be determined by the Geotechnical Consultant based on the field evaluation of exposed conditions during grading. Where fill-over-cut slopes are to be graded, the cut portion of the slope shall be made, evaluated, and accepted by the Geotechnical Consultant prior to placement of materials for construction of the fill portion of the slope, unless otherwise recommended by the Geotechnical Consultant.

7.0 Trench Backfills

7.1 The Contractor shall follow all OHSA and Cal/OSHA requirements for safety of trench excavations.

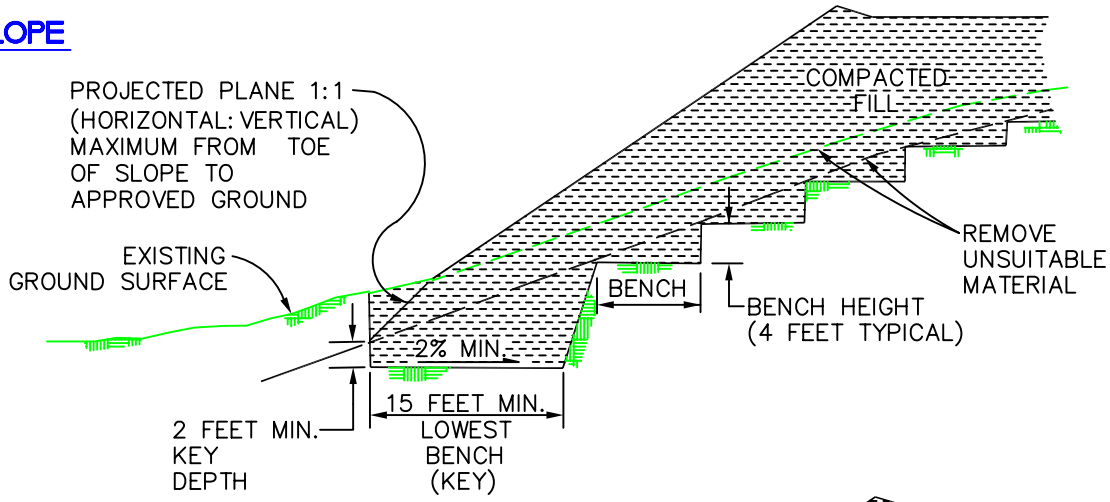
7.2 All bedding and backfill of utility trenches shall be done in accordance with the applicable provisions of Standard Specifications of Public Works Construction. Bedding material shall have a Sand Equivalent greater than 30 (SE>30). The bedding shall be placed to 1 foot over the top of the conduit and densified by jetting. Backfill shall be placed and densified to a minimum of 90 percent of maximum from 1 foot above the top of the conduit to the surface.

7.3 The jetting of the bedding around the conduits shall be observed by the Geotechnical Consultant.

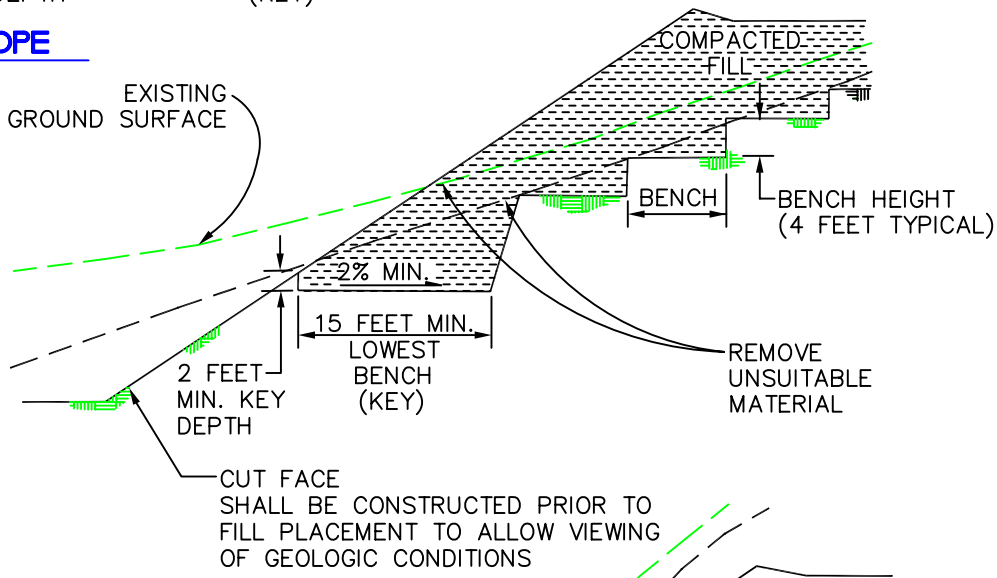
7.4 The Geotechnical Consultant shall test the trench backfill for relative compaction. At least one test should be made for every 300 feet of trench and 2 feet of fill.

7.5 Lift thickness of trench backfill shall not exceed those allowed in the Standard Specifications of Public Works Construction unless the Contractor can demonstrate to the Geotechnical Consultant that the fill lift can be compacted to the minimum relative compaction by his alternative equipment and method.

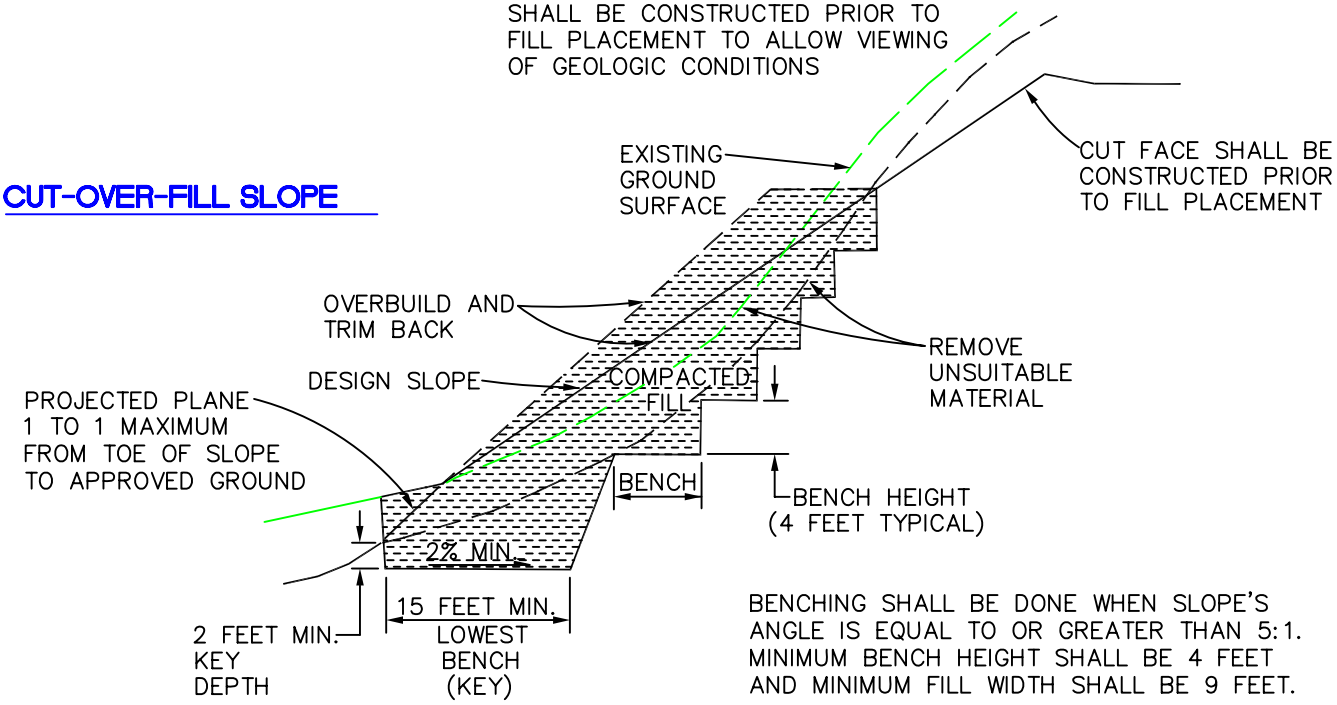
FILL SLOPE



FILL-OVER-CUT SLOPE

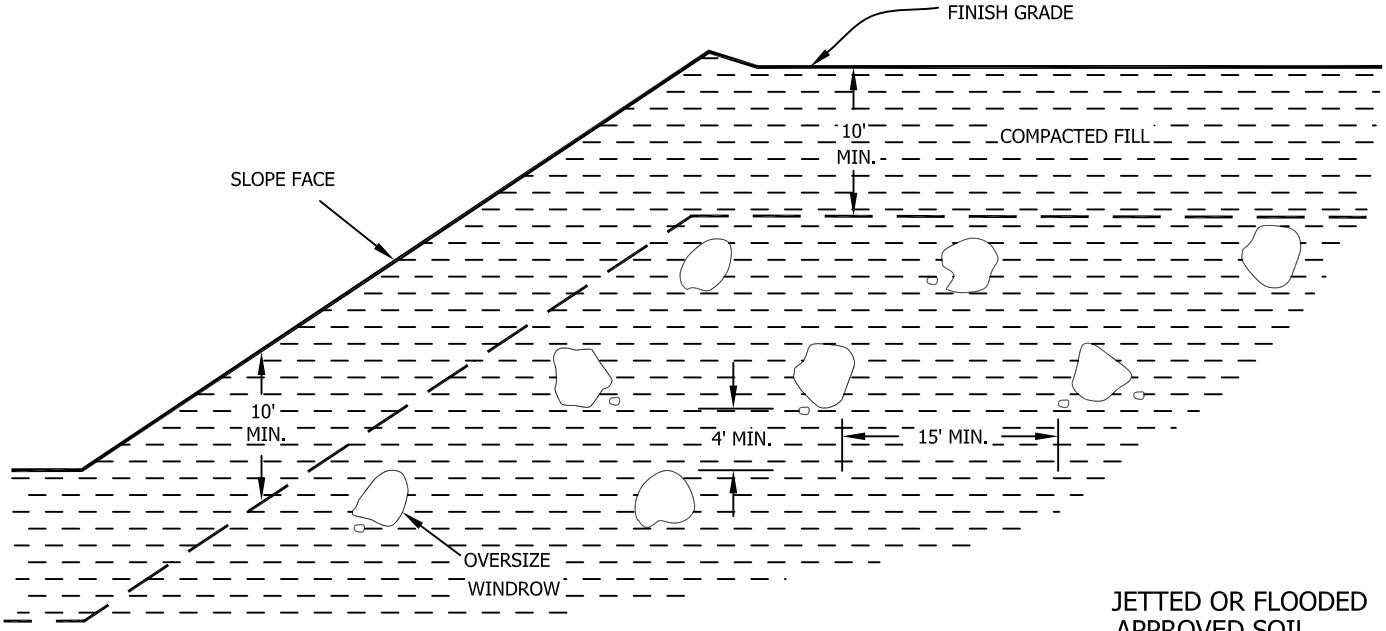


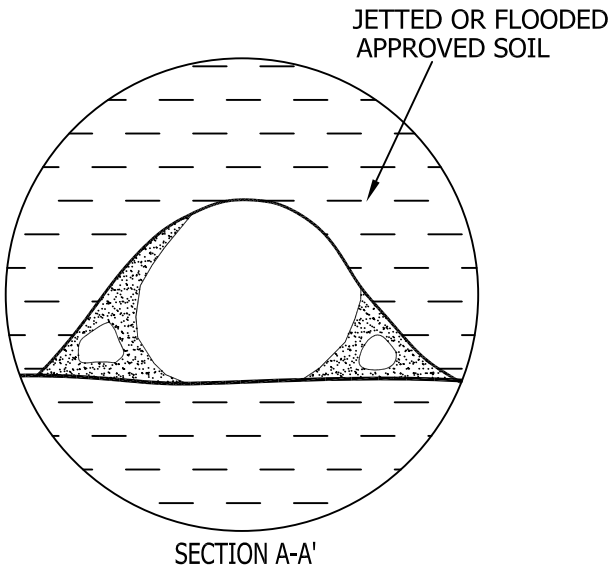
CUT-OVER-FILL SLOPE



BENCHING SHALL BE DONE WHEN SLOPE'S ANGLE IS EQUAL TO OR GREATER THAN 5:1. MINIMUM BENCH HEIGHT SHALL BE 4 FEET AND MINIMUM FILL WIDTH SHALL BE 9 FEET.

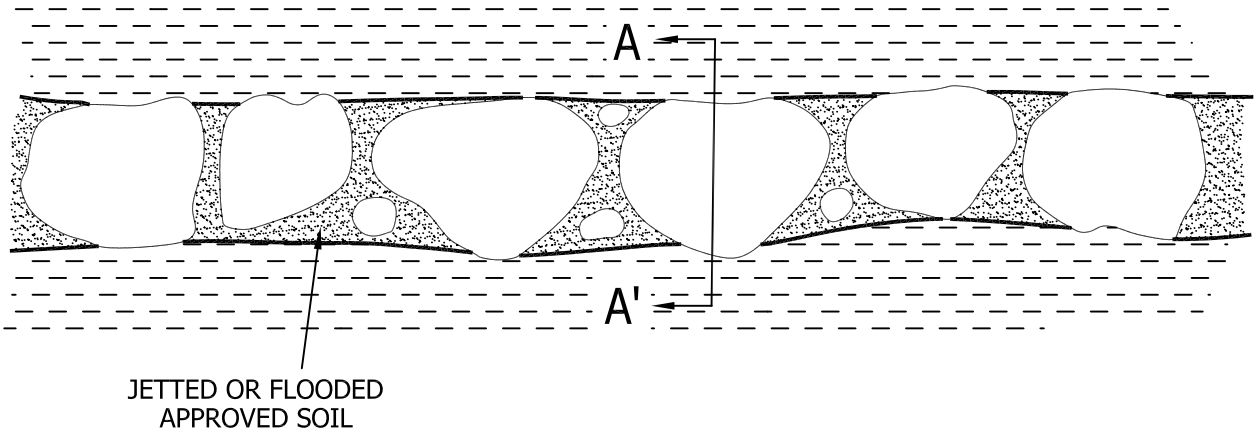
KEYING AND BENCHING	GENERAL EARTHWORK AND GRADING SPECIFICATIONS STANDARD DETAILS A	Leighton





- Oversize rock is larger than 8 inches in largest dimension.
- Backfill with approved soil jetted or flooded in place to fill all the voids.
- Do not bury rock within 10 feet of finish grade.
- Windrow of buried rock shall be parallel to the finished slope face.

PROFILE ALONG WINDROW



OVERSIZE ROCK DISPOSAL	GENERAL EARTHWORK AND GRADING SPECIFICATIONS STANDARD DETAILS B	Leighton

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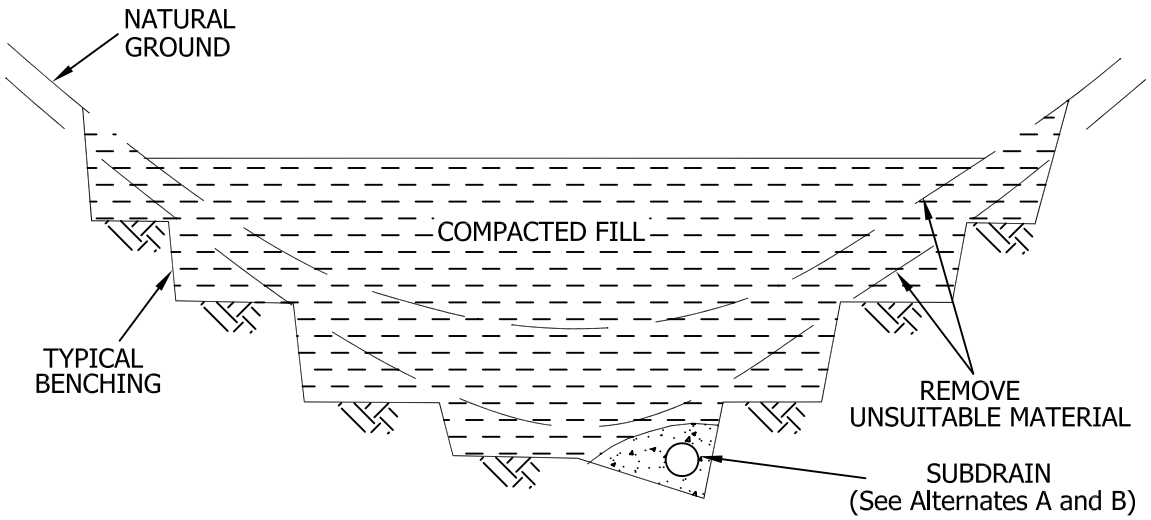
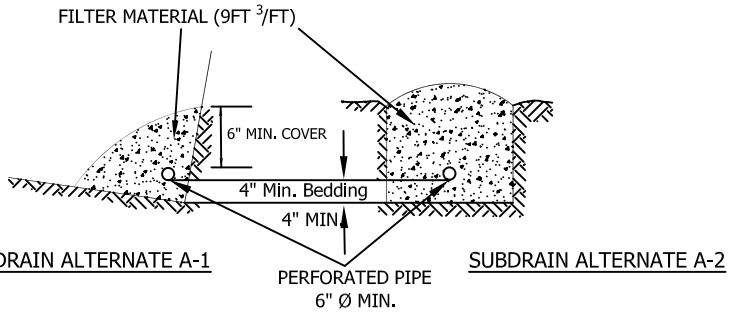


SUBDRAIN ALTERNATE A

PERFORATED PIPE SURROUNDED WITH FILTER MATERIAL

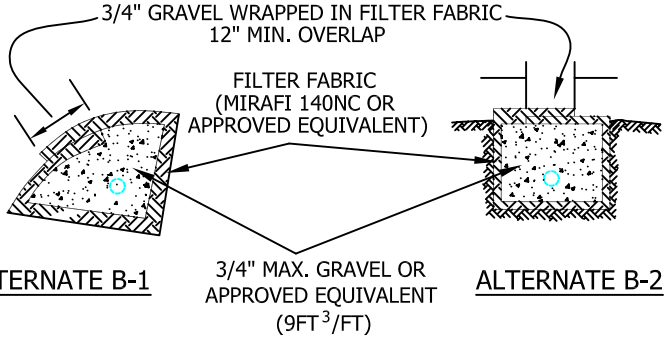


FILTER MATERIAL

FILTER MATERIAL SHALL BE CLASS 2 PERMEABLE MATERIAL PER STATE OF CALIFORNIA STANDARD SPECIFICATION, OR APPROVED ALTERNATE. CLASS 2 GRADING AS FOLLOWS:

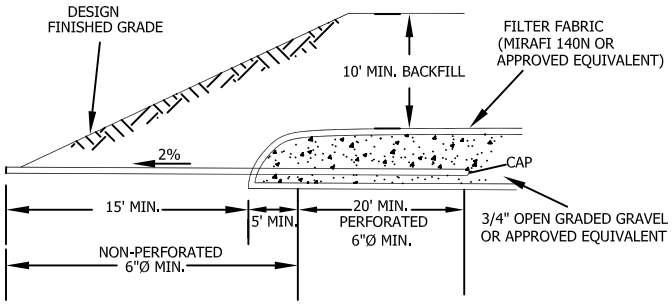
Sieve Size	Percent Passing
1"	100
3/4"	90-100
3/8"	40-100
No. 4	25-40
No. 8	18-33
No. 30	5-15
No. 50	0-7
No. 200	0-3

SUBDRAIN ALTERNATE B



○ PERFORATED PIPE IS OPTIONAL PER GOVERNING AGENCY'S REQUIREMENTS

DETAIL OF CANYON SUBDRAIN TERMINAL



CANYON SUBDRAIN	GENERAL EARTHWORK AND GRADING SPECIFICATIONS STANDARD DETAILS C	Leighton

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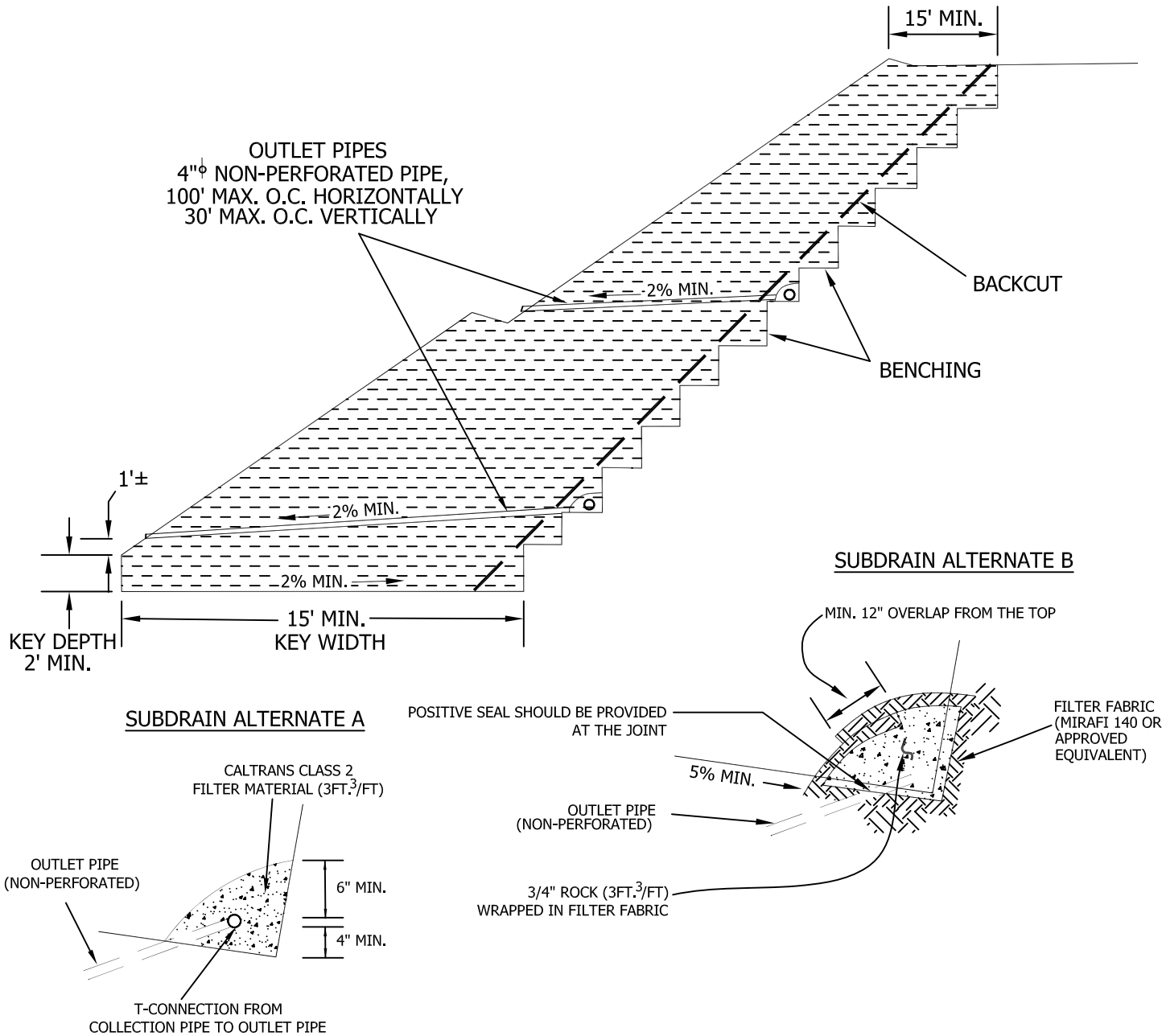

- SUBDRAIN INSTALLATION - Subdrain collector pipe shall be installed with perforations down or, unless otherwise designated by the geotechnical consultant. Outlet pipes shall be non-perforated pipe. The subdrain pipe shall have at least 8 perforations uniformly spaced per foot. Perforation shall be 1/4" to 1/2" if drilled holes are used. All subdrain pipes shall have a gradient at least 2% towards the outlet.
- SUBDRAIN PIPE - Subdrain pipe shall be ASTM D2751, ASTM D1527 (Schedule 40) or SDR 23.5 ABS pipe or ASTM D3034 (Schedule 40) or SDR 23.5 PVC pipe.
- All outlet pipe shall be placed in a trench and, after fill is placed above it, rodded to verify integrity.

BUTTRESS OR REPLACEMENT FILL SUBDRAINS	GENERAL EARTHWORK AND GRADING SPECIFICATIONS STANDARD DETAILS D	Leighton

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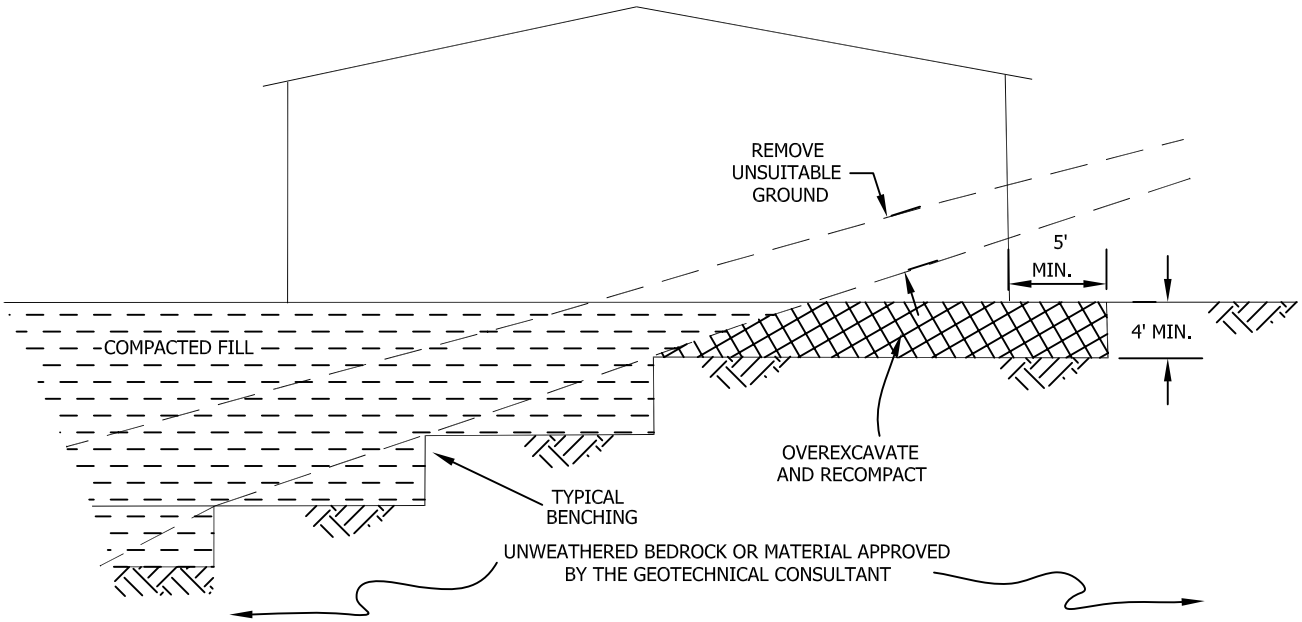
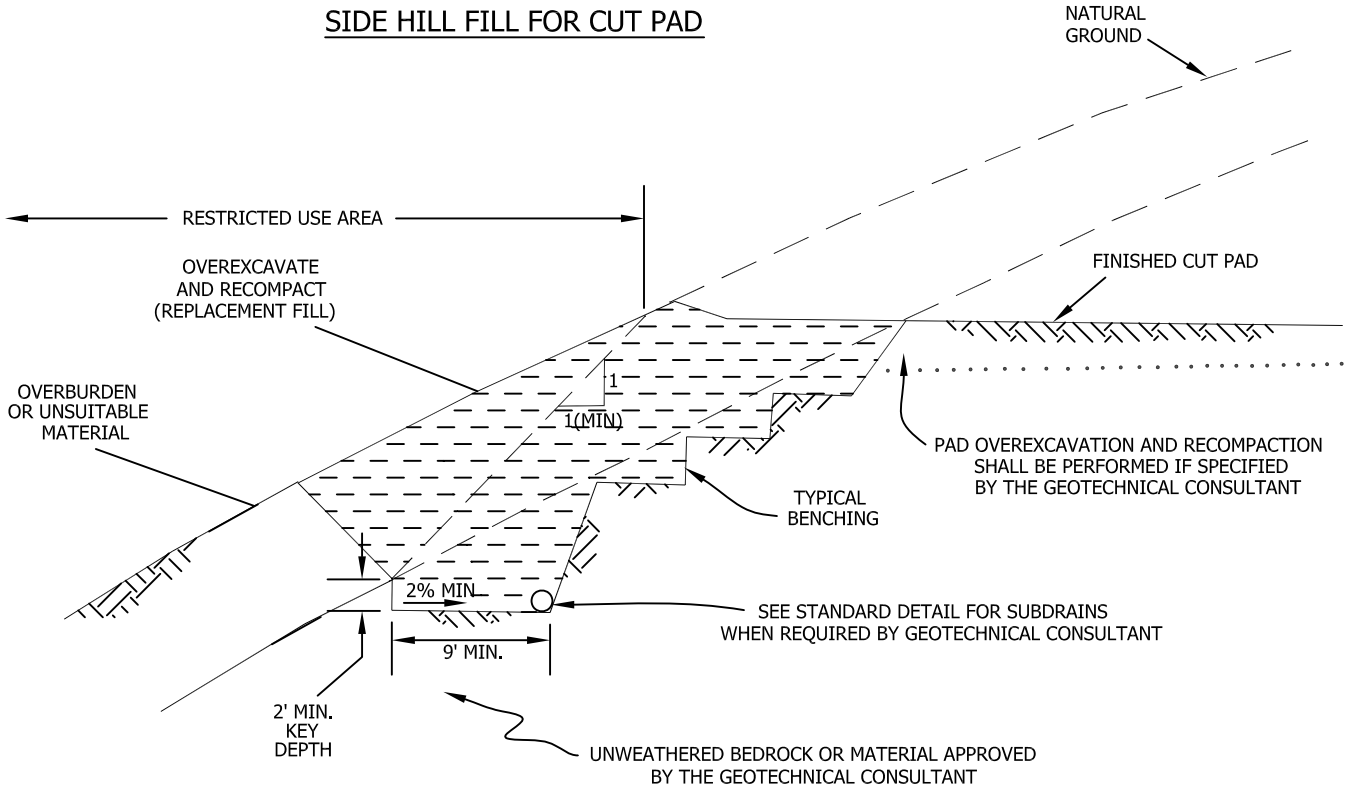
CUT-FILL TRANSITION LOT OVEREXCAVATION



SIDE HILL FILL FOR CUT PAD



TRANSITION LOT FILLS AND SIDE HILL FILLS	GENERAL EARTHWORK AND GRADING SPECIFICATIONS STANDARD DETAILS E	Leighton

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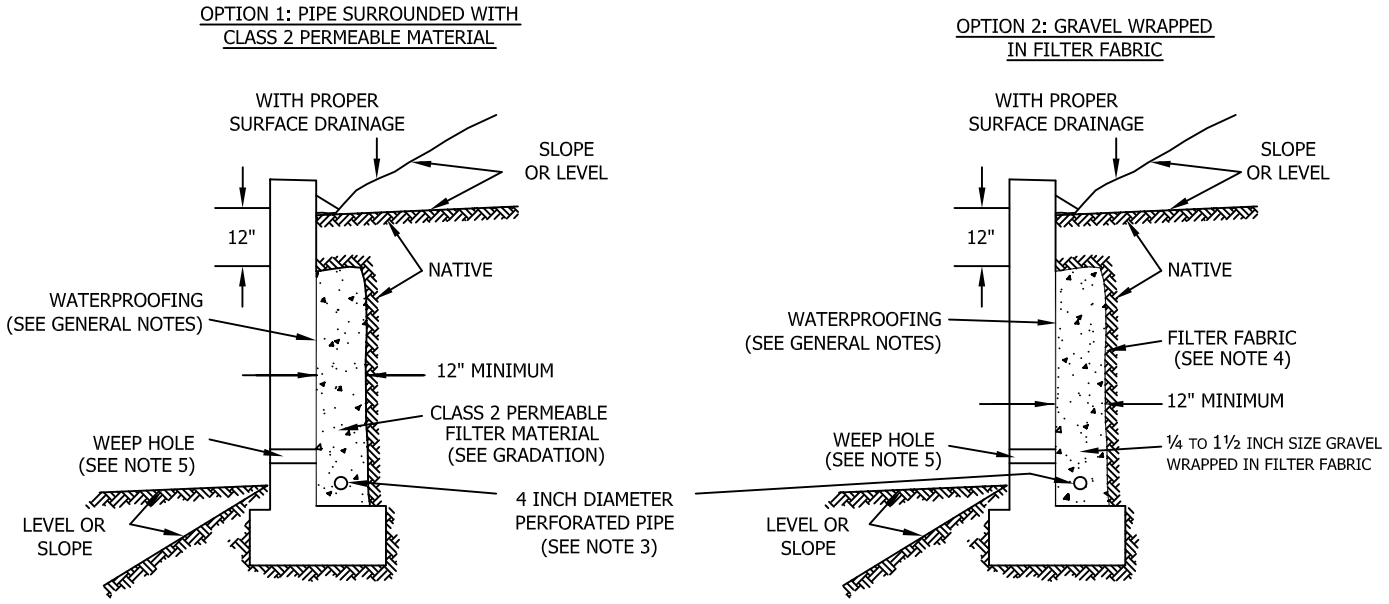
SUBDRAIN OPTIONS AND BACKFILL WHEN NATIVE MATERIAL HAS EXPANSION INDEX OF ≤50



Class 2 Filter Permeable Material Gradation
Per Caltrans Specifications

Sieve Size	Percent Passing
1"	100
3/4"	90-100
3/8"	40-100
No. 4	25-40
No. 8	18-33
No. 30	5-15
No. 50	0-7
No. 200	0-3

GENERAL NOTES:

* Waterproofing should be provided where moisture nuisance problem through the wall is undesirable.
* Water proofing of the walls is not under purview of the geotechnical engineer
* All drains should have a gradient of 1 percent minimum
*Outlet portion of the subdrain should have a 4-inch diameter solid pipe discharged into a suitable disposal area designed by the project engineer. The subdrain pipe should be accessible for maintenance (rodding)
*Other subdrain backfill options are subject to the review by the geotechnical engineer and modification of design parameters.

Notes:
1) Sand should have a sand equivalent of 30 or greater and may be densified by water jetting.
2) 1 Cu. ft. per ft. of 1/4- to 1 1/2-inch size gravel wrapped in filter fabric
3) Pipe type should be ASTM D1527 Acrylonitrile Butadiene Styrene (ABS) SDR35 or ASTM D1785 Polyvinyl Chloride plastic (PVC), Schedule 40, Armco A2000 PVC, or approved equivalent. Pipe should be installed with perforations down. Perforations should be 3/8 inch in diameter placed at the ends of a 120-degree arc in two rows at 3-inch on center (staggered)
4) Filter fabric should be Mirafi 140NC or approved equivalent.
5) Weephole should be 3-inch minimum diameter and provided at 10-foot maximum intervals. If exposure is permitted, weepholes should be located 12 inches above finished grade. If exposure is not permitted such as for a wall adjacent to a sidewalk/curb, a pipe under the sidewalk to be discharged through the curb face or equivalent should be provided. For a basement-type wall, a proper subdrain outlet system should be provided.
6) Retaining wall plans should be reviewed and approved by the geotechnical engineer.
7) Walls over six feet in height are subject to a special review by the geotechnical engineer and modifications to the above requirements.

RETAINING WALL BACKFILL AND SUBDRAIN DETAIL FOR WALLS 6 FEET OR LESS IN HEIGHT

WHEN NATIVE MATERIAL HAS EXPANSION INDEX OF ≤50

Leighton

Figure